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(71) Applicant: NISSAN MOTOR CO., LTD.
No.2, Takara-cho, Kanagawa-ku
Yokohama-shi Kanagawa-ken 221(JP)

(72) Inventor: Obara, Hideo
68, Oppamahigashi-cho 3-chome
Yokosuka-shi Kanagawa-ken(JP)

(72) Inventor: Yanagishima, Takayuki
1-7-404, Maborikaigan 4-chome
Yokosuka-shi Kanagawa-ken(JP)

(72) Inventor: Seko, Yasutoshi
2781-19, Tomioka Kanazawa-ku
Yokohama-shi Kanagawa-ken(JP)

(74) Representative: Patentanwälte TER MEER - MÜLLER - STEINMEISTER
Mauerkircherstrasse 45
D-8000 München 80(DE)

(54) **System and method for detecting and warning of drowsy driving of a vehicle.**

(57) In a drowsy driving detection system, drowsiness is recognized when an extended period without any steering adjustments is followed by abrupt steering corrections, of at least minimal speed and extent, in both directions. The minimal speed values are selected in accordance with the detected angular extent of each steering correction. The extent of each steering correction may be subdivided into a number of ranges, each associated with a predetermined reference minimal steering speed value. The reference speed value selection process may be applied to the steering corrections in either or both directions.

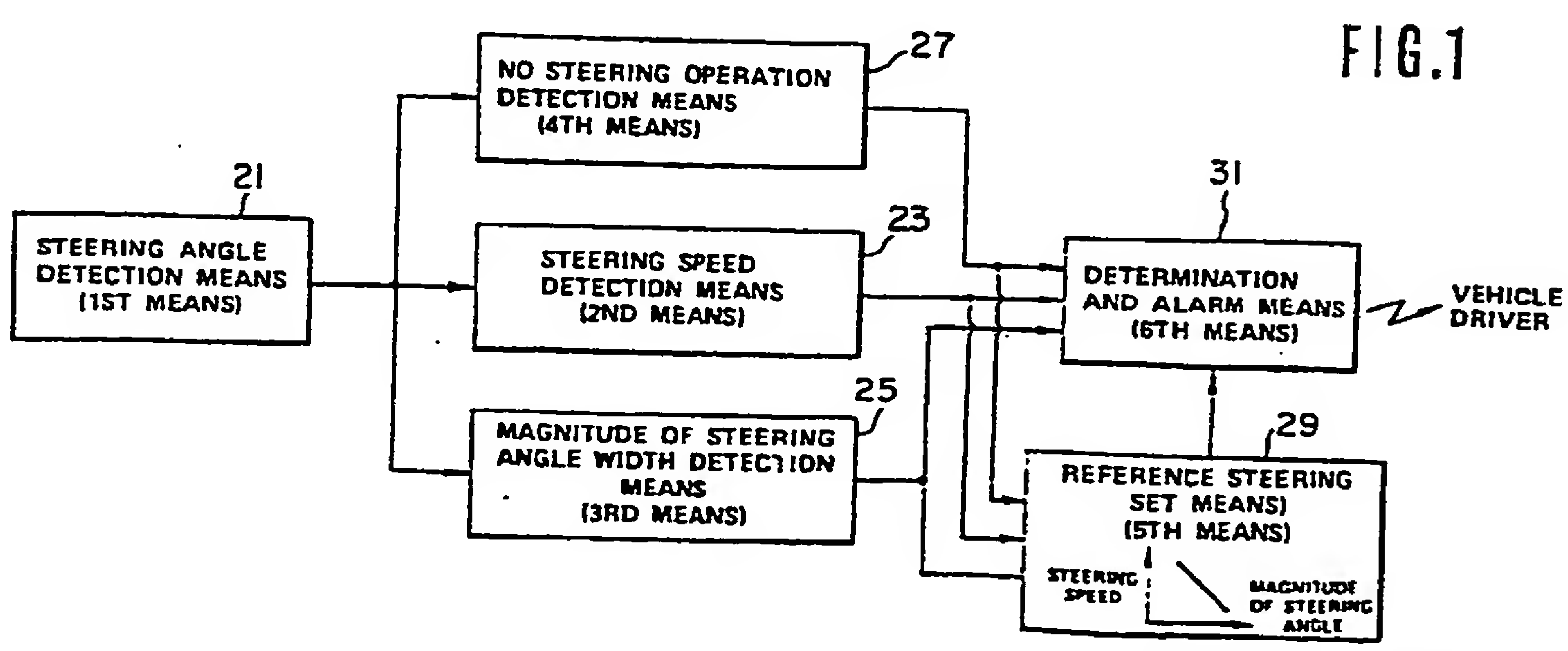

FIG.1

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SYSTEM AND METHOD FOR DETECTING AND WARNING OF DROWSY DRIVING OF A VEHICLE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a system and method for detecting drowsy driving of a vehicle on the basis of steering behavior and notifying the drowsy driver of same in order to improve driving safety.

Description of the Prior Art

Various drowsiness alarm systems have conventionally been proposed to prevent the vehicle driver from getting drowsy while driving. Japanese Utility Model Registration Publication No. Sho 58-23713 discloses such a drowsiness alarm system. The theory of operation on the alarm system disclosed in the above-identified document will be described below.

Since the vehicle driver generally tends to lose concentration with regard to steering when he gets drowsy (that is, the degree of alertness is reduced), so that extended periods without steering correction will occur intermittently. After such no steering operations, the driver will become awake and try to abruptly correct the steering. As a result, there is a tendency for the steering rate through a given angle of steering to greater, i.e. more abrupt, than during normal, alert driving.

On the basis of the above-described phenomenon, the drowsiness alarm system disclosed in the above-identified document recognizes that the driver is getting drowsy when a period without steering adjustments continues for a predetermined period of time and is followed by a steering operation in which the steering speed over a given angular extent exceeds a predetermined speed.

The conventional drowsiness alarm system

produces an alarm upon detection of drowsy driving on the basis of steering behavior indicative of the driver waking up. Thus, the alarm is produced after the driver has awakened so as to reliably prevent subsequent drowsy driving.

On the other hand, further experiments have indicated that judging from repeated measurement of the magnitude and angular speed of a unidirectional steering adjustment performed after a period without steering adjustments the possibility that the driver is losing alertness is high even though a high steering speed is evident only over a smaller range of unidirectional steering correction and the distinction between alertness and drowsiness is possible even in cases where the unidirectional steering correction is large but the steering speed is relatively slow.

SUMMARY OF THE INVENTION

With the above-described experimental results in mind, it is a primary object of the invention to provide a system and method for detecting and warning of drowsy driving of a vehicle, which can detect the driver drowsiness promptly and accurately.

To achieve the above-described object, the system for detecting and warning of drowsy driving of a vehicle with reference to Fig. 1 comprises: first means for detecting rotation of a steering wheel of the vehicle through unit angle and detecting the direction of rotation thereof; second means for detecting the angular rate at which the steering wheel is rotated on the basis of output signals from the first means; third means for detecting the angular extent through which the steering wheel is rotated in a given direction on the basis of the output signals from said first means; fourth means for detecting periods during which no steering wheel rotation occurs for at least a predetermined length of time on the basis of the output signals from the first means; fifth

means for setting reference values of the angular rate and extent of steering wheel rotation in a given direction after a period of no steering wheel rotation detected by the fourth means; and sixth means for producing an alarm when both the angular rate and extent of steering wheel rotation detected by the second and third means, after the fourth means detects the occurrence of a period of no steering wheel rotation, exceed the respective reference values.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete understanding of the present invention may be obtained from the foregoing description and attached drawings in which like reference numerals designate corresponding elements, in which:

Fig. 1 is a simplified functional block diagram of the system for detecting and warning of drowsy driving of a vehicle according to the present invention;

Fig. 2 is a diagram of the hardware of the embodiment shown in Fig. 1;

Figs. 3(A) and 3(B) are diagrams of the function of the components shown in Fig. 2;

Figs. 4, 5(a), and 5(b) are flowcharts for use in a first preferred embodiment according to the present invention;

Fig. 6 is a diagram of the theory of detection of drowsy driving employed in the present invention;

Fig. 7 is a graph representing how reference values for detecting drowsy driving in the first preferred embodiment are set;

Figs. 8, 9(a), 9(b), 9(c), and 9(d) are operational flowcharts for use in a second preferred embodiment according to the present invention;

Fig. 10 is a graph representing how reference values for detecting drowsy driving in the second preferred embodiment are set;

Figs. 11 and 12(a) through 12(d) are respective

operational flowcharts of a third preferred embodiment according to the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference will be made to the drawings in order to facilitate understanding of the present invention.

Fig. 2 shows the structure of a first preferred embodiment of a system for detecting and warning of drowsy driving.

Numeral 1 denotes a steering angle sensor. The structure of the steering angle sensor is disclosed in U.S. Patent applications Serial Nos. 580,174, 580,175, 580,177, and 580,178 filed on 15th February, 1984. U.S. Patent applications Serial No. 580,174 corresponds to EPC Patent application filing No. 8410645.4, Serial No. 580,175 to filing No. 8410668.6, Serial No. 580,177 to filing No. 84101646.2, Serial No. 580,178 to filing No. 8410667.8, these EPC applications being filed on February 17, 1984. The contents of these documents are hereby incorporated by reference. Numeral 5 denotes means for recognizing drowsy driving from output signals of the steering angle sensor 1 by way of a processing flowchart, to be described later, and actuating alarm means 7 upon recognition of drowsy driving. The detecting means 5 comprises a microcomputer having a CPU 9, ROM 11, RAM 13, and I/O port 15.

The steering angle sensor 1, as shown in Fig. 2 includes: (a) a disk 18 which rotates with the angular movement of a steering wheel (not shown) and is provided with a plurality of slits 14' arranged radially symmetrically around its periphery, each slit 14' having a width $\theta s-\alpha$; (b) a photo-interrupter module 19 having a pair of photo interrupters 19-1 and 19-2 opposite the disk 18 and producing two rectangular-wave electrical signals to be described later as the disk 18 rotates and passes the photo interrupter module 19. The pair of photo interrupters 19-1 and 19-2 are arranged to be

separated by n x $\theta s + 5\theta s/2$ (n = 0, 1, ...) so that the photo interrupters can resolve a minimum displacement of $\theta s/2$. Output signals of the photo interrupter modules 19 have respective fixed phase difference of $\theta s/2$, as appreciated from Fig. 3(B). The combination of the levels of the output signals provides the basis for determining the rotational direction of the steering wheel, as will be described later. It should be noted that in Fig. 3(A) reference symbol Z denotes the boundary between the presence or absence of the output signals of the photo interrupter module 19 and θs denotes a predetermined angular unit of steering adjustment.

The operation of the first preferred embodiment will be described below as controlled by processing flow of the CPU 9 shown in Fig. 4 and Fig. 5. First, however, the theory of detection for the drowsy driving in the first preferred embodiment will be described.

In general, as shown in Fig. 6, when the degree of alertness of the driver is excessively low, the driver may tend to correct his steering confusedly upon returning to full consciousness after a period of no steering adjustments. In such cases, steering pulses as shown in Fig. 6 will reflect the history of steering adjustments.

That is, the history of steering wheel movement in the above-described case can roughly be divided into three regimes: (a) a no-steering adjustment period; (b) a continuously unidirectional steering adjustment after the no-steering adjustment period (first steering operation); and (c) a continuously unidirectional steering adjustment in the direction opposite that of the first steering operation (second steering operation).

In this embodiment, detection of drowsy driving is based on the above-described first steering operation. In this detection method, a reference

steering speed is selected according to the total angular steering change of the above-described first steering operation, and drowsy driving is recognized on the basis of the results of comparison between the average steering speed over the first steering operation and the reference steering speed.

Execution of this method can be roughly divided into the processing steps shown in Fig. 4.

The CPU 9 executes seven consecutive steps 50, 52, 54, 56, 58, 60, and 62. The purpose of step 50 is to determine whether a prerequisite for detecting drowsy driving is satisfied. The purpose of step 52 is to measure the duration of no-steering adjustment period. The purpose of step 54 is to determine whether a predetermined no-steering condition is satisfied. The purpose of step 56 is to record the number and timing of pulses received from the steering angle sensor 1 after a recognized no-steering adjustment period. The purpose of step 58 is to determine whether the number of received pulses satisfies a preset condition. The purpose of step 60 is to determine whether the average angular steering adjustment speed over the first steering operation calculated on the basis of the inter-pulse intervals satisfies preset conditions. The purpose of step 62 is to actuate an alarm when the conditions in step 60 are satisfied.

The detailed processing carried out in the first preferred embodiment will be described with reference to Figs. 5(a) and 5(b).

In a first step 100, the CPU 9 determines whether a condition prerequisite to starting detection of drowsy driving is satisfied. The prerequisite condition may be, for example, whether the vehicle speed exceeds a predetermined speed (e.g., 70 km/h). If the prerequisite condition is satisfied in the step 100, the routine goes to the next step 110 to start monitoring for drowsy

driving. In the step 110, a timer A starts to measure the duration for which no adjustments of the steering wheel are made. In step 120, the elapsed time Ta measured by timer A is compared with a predetermined period of time Ao (for example, three seconds) so as to determine whether a no-steering adjustment period has occurred. If a steering pulse from the steering angle sensor 1 is received within the predetermined period of time Ao in the step 130, the timer A is cleared in step 140 and the routine returns to the step 110.

If Ta $\geq$ Ao in the step 120, the routine goes to step 150 to wait for subsequent steering pulses. When the first steering pulse after the no-steering adjustment period is received in the step 150, its polarity is stored in a register PF_N in step 160 and timer B is actuated in step 170. In step 180, the CPU 9 waits for the next steering pulse. When the next steering pulse (second pulse) is received in the step 180, the direction of the second pulse is stored in register PF_{N+1}. Thereafter, the CPU 9 determines in step 200 whether the directions indicated by the contents of the registers PF_N and PF_{N+1} are the same. If $(PF_N) = (PF_{N+1})$ in the step 200, the routine goes to step 210. If $(PF_N) \neq (PF_{N+1})$ in the step 200, the routine goes to step 211. When Tb < Ao in the step 211, i.e., when the interval of time between the first steering pulse and second steering pulse measured by means of timer B is shorter than the above-described predetermined period of time Ao, the CPU 9 determines that the drowsy driving is not occurring, clears all timers in step 212, sets the contents of a pulse count register N for storing the number of steering pulses in the first steering operation to "1" (steps 212, 213), and the routine returns to the step 110 to restart the detection of drowsy driving. In addition, if Tb $\geq$ Ao in step 211, the timer B is cleared in step 214, the pulse count register N is set to "1" in step 215, and the

routine goes to step 150 in order to detect the drowsy driving starting after this newly-detected no-steering operation period since the second pulse received in the step 180 is not derived from the same episode of drowsy driving, if any, as the steering pulse determined in the step 180.

On the other hand, if the first and second pulses are in the same direction in the step 200, the routine goes to the step 210 wherein the measured time Tb of the timer B is compared with the above-described predetermined period of time Ao. If Tb < Ao in the step 210, the routine goes to step 240; in this case, there is a possibility that the first and second pulses may be derived from steering operations subsequent to no-steering operation period due to the drowsy driving. If Tb $\geq$ Ao in the step 210, the CPU 9 recognizes that another no-steering operation period is occurring and that the second pulse received in the step 180 is not due to drowsy driving and the routine goes to steps 220 and 230 wherein the timer B is cleared and the pulse count register S is set to "1" and then control returns to step 150.

In the step 240, the contents of pulse count register N is incremented (N=N+1) in step 250 and the input interval of time $t_1(N)$ between the first pulse and second pulse received in the steps 150 and 180 respectively is stored in a steering speed register TS_1 in step 260.

A "drowsy driver" alarm is to be produced when the combination of the value of the pulse count register N and the accumulated time ($\Sigma t_1(N)$) falls into the oblique region shown in Fig. 7, as determined in steps 270 through 350. That is to say, as the total steering angle change of the first steering operation subsequent to no-steering operation (i.e., the value of the pulse count regiser N) increases, a reference steering speed

related to the magnitude of the steering angle change also increases. In this case, the CPU 9 recognizes the occurrence of drowsy driving if the accumulated time ($\Sigma t_1(N)$) is less than a predetermined period of time representing a reference steering speed. In other words, when the accumulated time is shorter than the predetermined period of time representing the reference steering speed, the CPU 9 recognizes that the average steeringspeed over the first steering operation exceeds the reference steering speed. It should be noted that if the CPU 9 recognizes that the drowsy driving has not occurred, i.e. if any of the preconditions for drowsy driving are not satisfied at any time during the steps 270 through 330, control returns to the step 170 in order to continue monitoring for drowsy driving. Furthermore, if the condition of step 340 is not satisfied, the CPU 9 recognizes that the drowsy driving has not occurred, clears the timer B in step 360, and returns to the step 110 to restart detection of drowsy driving.

It should be noted that K0, K1, K2, K3, and K4 shown in the steps 270, 290, 310, and 330 denote reference steering angle changes delimiting ranges of the reference steering speed (the values of the pulse count register N). One exemplary system uses three for K0, six for K1, nine for K2, twelve for K3, fifteen for K4. In addition, K5, K6, K7, and K8 denote predetermined periods of time representing the reference steering speed. The exemplary system uses 0.1 seconds for K5, 0.5 seconds for K6, 1 second for K7, and 2 seconds for K8.

Fig. 8 and Figs. 9(a) through 9(d) are general and detailed flowcharts of a second preferred embodiment. The circuit configuration is the same as that of the first preferred embodiment shown in Figs. 2 and 3. The distinguishing feature of the second preferred embodiment is that the system recognizes drowsy driving when the durations of both first and second steering

operations are shorter than the predetermined periods of time representing the respective reference steering speeds set on the basis of the corresponding total steering angle changes.

Fig. 8 illustrates the general flow of processing in detecting drowsy driving: (a) step 70 to determine whether a condition prerequisite to detecting drowsy driving is satisfied; (b) step 72 to measure the duration of time during which no steering operations are performed; (c) step 74 to determine whether the criteria for identifying a no-steering operation period are satisfied; (d) step 76 to measure the number of pulses and the intervals of time between pulses of the first steering operation, which occurs after the no-steering operation period; (e) step 78 to recognize the occurrence of the first steering operation comprising step 78-1 to determine whether a criterion for the measured number of pulses is satisfied and step 78-2 to determine whether a criterion for the steering speed of the first steering operation calculated on the basis of the measured intervals of time is satisfied; (f) step 80 to measure the number of steering pulses and pulse intervals received from the steering angle sensor 1 during a second steering operation carried out after the first steering operation; (g) step 82 to recognize the occurrence of the second steering operation comprising step 82-1 to determine whether a criterion for the measured number of pulses is satisfied and step 82-2 to determine whether a criterion for the average steering speed over the second steering operation is satisfied; and (h) a conventional alarm step 84.

A detailed description of the second preferred embodiment will be made with reference to Figs. 9(a) through 9(d).

First, the routine goes to step 400 wherein the CPU 9 determines whether a predetermined prerequisite

condition is satisfied and goes to step 410 to start detection of drowsy driving after determining that the predetermined prerequisite condition is satisfied. The predetermined prerequisite condition is, for example, whether the vehicle speed is in excess of a predetermined value (for example, 70 km/h).

In the step 410, the CPU 9 starts a timer A in order to measure the duration of a no-steering operation period.

In the next step 420, the CPU 9 compares the value Ta of the timer A with a predetermined value Ao (,e.g., three seconds) in order to check for the occurrence of a no-steering operation prior to receipt of the next steering pulse. If, in subsequent step 430, a pulse is inputted within the predetermined period of time Ao, the routine goes to step 440 wherein the timer A is cleared and returns to the step 410 to restart the timer A.

If $Ta \geq Ao$ in the step 420, the routine goes to step 450, in which the CPU 9 waits for the next pulse from the steering angle sensor 1. After a pulse (first pulse) is received in the step 450, the direction indicated by the first pulse is stored in register PF_N in step 460 and thereafter the routine goes to step 470 wherein the timer B is set. Next, in step 480, the CPU 9 waits for the next steering pulse. After the next pulse (second pulse) is received, the direction indicated by the second pulse is stored in register PF_{N+1}. In step 500, the CPU 9 compares the contents of PF_N and PF_{N+1} to determine whether the first and second pulses were due to changes in the same direction. If they are derived from the same steering direction, the routine goes to step 510. If not, the routine goes to step 680. In the step 510, the CPU 9 compares the elapsed time Tb measured by the timer B with the predetermined period of time Ao in order to judge the presence or absence of a no-steering

operation. If Tb<Ao in the step 510, the routine goes to step 540; in this case, the second pulse received at step 480 may possibly be part of a first steering operation as defined above. On the other hand, if Tb≥Ao in the step 510, the timer B is cleared in the next step 520 since the second pulse received at the time of the step 480 is not indicative of drowsy driving. In order to restart detection of drowsy driving, the routine goes to step 530 wherein the contents of a pulse count register N is set to a "1" and then control returns to the step 450.

On the other hand, if Tb<Ao in the step 510, the routine goes to step 540 wherein the value in the pulse count register N is incremented (N=N+1) and then to step 550 wherein the interval of time t(N) between the first and second pulses received at steps 450 and 480 respectively is stored. In the next step 560, the value of interval of time $t_1(N)$ is added to the contents of steering speed register TS_1. In the subsequent steps 570-640, a series of cascading comparisons are made, as in steps 270-340 of Fig. 5, in order to first select the appropriate range (K_0-K_4) of the number of pulses in the unidirectional steering episode (i.e., N) and then to see if the total elapsed time TS_1 of the current—episode reflects a steering adjustment rate in excess of a preselected threshold rate suitable for the current pulse number range. As can be more easily visualized with reference to Fig. 7, since the preselected periods K_5-K_8 represent average angular velocity values over the total steering adjustments K_0-K_1, K_1-K_2 ... K_3-K_4 respectively, the steps 570-640 in effect check for an average steering rate in excess of a threshold which may itself be dependent on the total steering correction. If in fact the average steering rate is high enough to indicate an abrupt recovery from a lapse of attention, i.e. if elapsed time TS_1 is less than the appropriate threshold period K_5-K_8, then the program starts a timer C

in step 650 and in step 660 sets a flag X to indicate the occurrence of the first steering operation as defined above. If the average steering rate over a long unidirectional episode is too low to reflect drowsy driving, as may happen on curves etc., then timer B is cleared in step 670 and then drowsy driving detection is restarted from step 410. Otherwise, the steps 470-640 are repeated unitl one of the above conditions is satisfied.

It should also be noted that the reference steering angle changes K_0 through K_4 and reference steering speed-indicative periods K_5 through K_8 may be the same as those used in the first preferred embodiment.

The first time that a steering pulse of the opposite polarity is noted in step 500, control passes to step 680, wherein the value Tb of the timer B is compared with the above-described value Ao to check for a no-steering operation. Specifically, a no-steering operation is recognized if $Tb \geq Ao$ in the step 680. In this case, the routine returns to step 460 via steps 690 and 700 in which the timers are all cleared and the value of pulse count register N is set to "1". The process starts again from the detection of the first steering operation after the no-steering operation recognized in the step 680. If, on the other hand $Tb < Ao$ in step 680, the routine advances to step 710.

In the step 710, the timer B is cleared and then started in step 720. Thereafter, the CPU 9 awaits the arrival of the next pulse in step 730. Upon receipt of the next pulse (third pulse) in the step 730, the CPU 9 stores the direction indicated by the third pulse into register PF_M in step 740. Thereafter, the routine goes to step 750, wherein the CPU 9 determines whether the above-described flag X indicating the occurrence of the first steering operation is set. If the flag X is not yet set, the CPU 9 determines whether the value Tb of

the timer B set in the step 720 is in excess of the above-described predetermined value Ao in order to check for a no-steering operation in step 760. If Tb≧Ao in step 760, all the timers are cleared in the step 690, the value of the pulse count register N is set to "1" in the step 700, and the routine returns to the step 460 to await the occurrence of the first steering operation. If Tb<Ao in the step 760, all the timers are cleared in step 770 and the value of the pulse count register N is set to "1" and the value of another pulse count register M for storing the number of pulses relating to the second steering operation is set to "0" in step 780. Thereafter, the routine returns to the step 410 to await the occurrence of a no-steering operation. That is to say, in this process, establishment of both conditions X=0 and Tb<Ao indicates that the driver is turning the steering wheel back and forth as part of normal, alert steering control. Therefore, since drowsy driving is not occurring, detection of drowsy driving is again started by awaiting the occurrence of a no-steering operation. On the other hand, if the flag X is set, the routine goes from the step 750 to step 790 in order to check for the occurrence of a second steering operation.

In the step 790, the CPU 9 determines whether the steering pulse received at the step 730 is derived from a steering adjustment in the same direction as the second steering operation. If the last two pulses were in the same direction when checked at step 790, the routine goes to step 890 to proceed with detection of the second steering operation. If a direction reversal is detected by step 790, the routine goes to step 800. In the step 800, the CPU 9 compares the contents Tb of the timer B with the above-described predetermined value Ao to check for a no-steering operation. If Tb≧Ao in the step 800, i.e. if another no- steering operation has occurred, all the timers are cleared in step 810, the

values of the two pulse count registers N and M are set to "1" and "0" respectively in step 820, and the flag X is reset to "0" in step 830. Thereafter, the routine returns to step 450. On the other hand, if Tb<Ao in the step 800, the routine goes to the step 840 wherein the CPU 9 compares the time count Tc in the timer C with a reference time K_{21} (, e.g. three seconds) representing the longest expectable interval from the end of the first steering operation to the end of the second steering operation.

If $Tc \geqq K_{21}$ in the step 840, the CPU 9 determines that the second steering operation has not occurred within the above-described reference time K_{21} and therefore that no drowsy driving has occurred. In the next step 850, all the timers are cleared. In the next step 860, the pulse count registers N and M are set to "1" and "0", respectively. In the next step 870, the flag X described above is reset to "0". Thereafter, the routine returns to the step 410 in order to restart the detection of drowsy driving from the beginning. On the other hand, if elapsed time Tc is still less than reference time K_{21} when checked at step 840, then the pulse count register M is cleared in step 880 and control returns to step 710. This erases the information about the second steering operation, if any, but allows the program to continue checking for the second steering operation without starting again from the beginning. Thus, if a few pulses in the reverse direction should occur during the second steering operation within the period K_{21}, these can be ignored without influencing the average steering rate estimates to be performed after completion of the second steering operation.

If the steering pulse received in step 740 is in the direction of the second steering operation when checked in the step 790, the routine goes to step 890. If Tb<Ao in the step 890, the CPU 9 decides that a

no-steering operation has not occurred and goes on to step 900, wherein the time count Tc in the timer C is compared with the above-mentioned reference time K_{21}. If $Tc<K_{21}$ in the step 900, the routine goes to step 910 et seq. to check whether or not a second steering operation has occurred. It should be noted that if $Tb \geq Ao$ in the step 890, the routine goes to the step 810 and if $Tc \geq K_{21}$ in the step 900, the routine goes to the step 850.

In the step 910, the contents of the pulse count register M is incremented (M=M+1), the interval of time $t_2(M)$ between the steering pulse received at step 730 described above and the steering pulse received immediately before the step 730 is stored in step 920. This time interval is added to the contents of a steering speed register TS_2 in step 930. Finally, the pulse count M and accumulated time $(\Sigma t_2(M))$ are processed to check for excessively high steering rate in steps 930 through 1020. In the processing required to recognize drowsy driving, the reference steering speed is set according to the magnitude of the steering correction, specifically reference steering speed is inversely proportional to the magnitude of the steering correction (the value of the pulse count register M).

In summary, the CPU 9 recognizes occurrence of a first steering operation if the above-described accumulated time $(\Sigma t_1(N))$ is within a predetermined time representing a reference steering speed. After the criteria for the first steering operation are satisfied, another reference steering speed is selected from the array shown in Fig. 10 according to the magnitude of steering correction (the value of the pulse count register M) in the case of the second steering operation in the direction opposite to the first steering operation. The CPU 9 decides that drowsy driving has occurred if the above-described accumulated time (TS_2) is within the predetermined time representing the second

reference steering speed.

It should be noted that if the criteria for drowsy driving are not satisfied in the process steps 940 through 1010, the routine returns to the step 710 to continue monitoring for the second steering operation. If the pulse count M is in the largest range shown in Fig. 10 but the accumulated TS_2 is greater than the reference time K_{20}, then control passes from step 1010 to step 1030, wherein all the timers are cleared. Thereafter, in the next step 1040, the values of the pulse count registers N and M are set to "1" and "0", respectively. Furthermore, after the flag X is reset to "0" in the next step 1050, the routine returns to the step 410 to restart drowsy driving detection from the beginning.

It should also be noted that in the above-described processing, K_0, K_{13}, K_{14}, K_{15}, and K_{16} denote reference magnitudes of the steering correction for setting the reference steering speed. In the exemplary system, in units of steering pulses (M), K_0 is one, K_{13} is three, K_{14} is six, K_{15} is none, and K_{16} is twelve. In addition, K_{17}, K_{18}, K_{19}, and K_{20} denote predetermined times representing the reference steering speed, e.g., one second, two seconds, three seconds, and four seconds, respectively.

Figs. 11 through 12(d) show a third preferred embodiment of the present invention. The distinctive feature of the present third preferred embodiment is that both the reference steering correction and the reference steering speed serving as criteria for the second steering operation are set on the basis of the reference steering correction and the reference steering speed of the first steering operation.

That is to say, as shown in the general flowchart of Fig. 11, extra processes are added to the flowchart of Fig. 8 in the step 78 in which the first

steering operation is confirmed and step 82 in which the second steering operation is confirmed. Specifically, these added substeps are step 78-3 which sets a criterion parameter serving as a precondition for the second steering operation on the basis of the steering behavior during the first steering operation and step 82-0 which selects a reference value serving as a criterion for confirmation of the second steering operation in accordance with the criterion parameter from the first steering operation.

In more detail, as shown in Figs. 12(a) through 12(d), the processing in the third preferred embodiment diverges from that of the second preferred embodiment in the manner described below.

When the occurrence of the first steering operation is confirmed in steps 560 through 640, added steps 585, 605, 625 and 645 first steering operation detection registers (X_1 through X_4) according to the reference steering angle (K_0 through K_4) and reference steering angle speed (K_5 through K_8) at which the occurrence of the first steering operation is first recognized. In addition, new steps 932, 934, 936 and 938 are added to the steps 940-1050 shown in Fig. 8(d) to detect which of the above-described first steering operation detection registers (X_1 through X_4) are set and to select a pair of reference values, which serve as criteria for recognition of the second steering operation, according to the range of the sum (ΣXi) of the values of the registers X_1-X_4 as defined by reference values K_9 through K_{11}. It should be noted that the reliance on the first steering operation detection flag X is redirected to the first steering operation detection registers in the third preferred embodiment. Furthermore, the structure of the third preferred embodiment is the same as that shown in Fig. 1 and Fig. 2 and the steps of the same numerals shown in Figs. 11

through 12(d) as those shown in Figs. 8 through 9(d) denote the same processes.

By way of example, the reference values K_9, K_{10}, and may be two, four and seven in the case where the registers X_1-X_4 are assigned either zero or their own subscript value.

As described above, since the system for detecting drowsy driving according to the present invention selects a reference steering speed threshold according to the magnitude of the first steering change immediately after the end of an extended no-steering period and confirms the occurrence of steering indicative of drowsy driving on the basis of the comparison between the reference steering speed and the average steering speed over the first steering operation, drowsy driving can be detected quickly and reliably.

It will fully be understood by those skilled in the art that the foregoing description is in terms of preferred embodiments and that various changes and modifications may be made without departing from the scope of the present invention, which is to be defined in the appended claims.

WHAT IS CLAIMED IS:

1. A system for detecting drowsy driving of a vehicle and warning a vehicle driver thereof, comprising:

a) first means (21) for detecting rotation of a steering wheel of the vehicle through a unit angle and detecting the direction of rotation thereof;

b) second means (23) for detecting the angular rate at which the steering wheel is rotated on the basis of output signals from said first means;

c) third means (25) for detecting the angular extent through which the steering wheel is rotated in a given direction on the basis of the output signals from said first means;

d) fourth means (27) for detecting periods during which no steering wheel rotation occurs for at least a predetermined length of time on the basis of the output signals from said first means;

e) fifth means (29) for setting reference values of the angular rate and extent of steering wheel rotation in a given direction after a period of no steering wheel rotation detected by said fourth means; and

f) sixth means (31) for producing an alarm when both the angular rate and extent of steering wheel rotation detected by said second and third means after said fourth means detects the occurrence of a period of no steering wheel rotation exceed the respective reference values.

2. The system as set forth in claim 1, wherein said sixth means (31) produces the alarm when both the angular rate and extent of steering wheel rotation in a single direction following a period of no steering wheel rotation exceed their respective reference values.

3. The system as set forth in claim 1, wherein said sixth means (31) produces the alarm when both the angular

rate and extent of steering wheel rotation in a first direction following a period of no steering wheel rotation exceed their respective reference values and both the angular rate and extent of steering wheel rotation in a second direction opposite said first direction immediately after the rotation in the first direction exceed their respective reference values.

4. The system as set forth in claim 3, wherein said fifth means (29) comprises:

a) a first setting section for setting said reference values, the reference steering rate value decreasing as the reference steering extent value increases; and

b) a second setting section responsive to the steering wheel rotation in the first direction for setting the reference steering rate value in accordance with the detected angular extent of said rotation in the first direction.

5. A system for detecting drowsy driving of a vehicle and warning a vehicle driver thereof, comprising:

a) first means (21) for detecting rotation of a steering wheel of the vehicle through a unit angle and detecting the direction of rotation thereof;

b) second means (23) for detecting the angular rate at which the steering wheel is rotated on the basis of consecutive output signals from said first means;

c) third means (25) for detecting the angular extent through which the steering wheel is rotated in a given direction on the basis of the output signals from said first means;

d) fourth means (27) for detecting periods during which no steering wheel rotation occurs for at least a predetermined length of time on the basis of the output signals from said first means;

e) fifth means (29) for setting references values of the angular rate and extent of steering wheel rotation after a period of no steering wheel rotation detected by said fourth means, the reference value of the steering rate being set according to the reference value of the extent of steering wheel rotation; and

f) sixth means (31) for producing an alarm when both the angular rate and extent of steering wheel rotation exceed their respective reference values.

6. The system as set forth in claim 5, wherein said fifth means (29) sets the reference value of the steering rate in such a way that as the reference value of the extent of steering wheel rotation increases, the reference value of steering speed rate decreases.

7. The system as set forth in claim 5, wherein said fifth means (29) sets the reference value of steering rate according to the detected extent of steering wheel rotation in a first direction immediately after a period of no steering wheel rotation detected by said fourth means and said sixth means produces the alarm when the detected rate and extent of the rotation of the first direction exceeds the corresponding reference values.

8. The system as set forth in claim 5, wherein said fifth means (29) sets said reference values of steering rate and extent for two successive steering wheel rotations in opposition directions and said sixth means produces the alarm when the angular rate and extent of steering wheel rotation in both the first and the second directions exceed the reference values of the steering rate and extent.

9. The system as set forth in claim 5, wherein said fifth means (29) sets the reference values for steering

wheel rotation in the second direction on the basis of the reference values of the steering wheel rotation in the first direction.

10. A method for detecting drowsy driving of a vehicle and warning a vehicle driver thereof, comprising the steps of:

a) determining whether a prerequisite for detecting drowsy driving is satisfied;

b) measuring an interval of time for which no steering adjustments are made;

c) selecting a reference value of steering speed according to a total angular range over which a unidirectioinal steering adjustment is made after a period of no steering adjustments exceeding a predetermined period of time; and

d) producing an alarm when the steering speed of said unidirectional steering adjustment exceeds the reference value of steering speed.

11. The method as set forth in claim 10, wherein the reference value of steering speed decreases as the total angular extent of the steering adjustment increases.

12. The method as set forth in claim 10, wherein reference values of steering speed are selected for both a first unidirectional steering adjustment after a period of no steering adjustment exceeding the predetermined period of time and a second unidirectional steering adjustment in the direction opposite to the first unidirectional steering adjustment independently.

13. The method as set forth in claim 10, wherein reference values of steering speed are selected for both a first unidirectional steering adjustment after a period

of no steering adjustments exceeding the predetermined period of time and a subsequent second unidirectional steering adjustment in the direction opposite to the first unidirectional steering adjustment the reference steering speed of the second unidirectional steering adjustment being based on that of the first unidirectional steering movement.

FIG.1

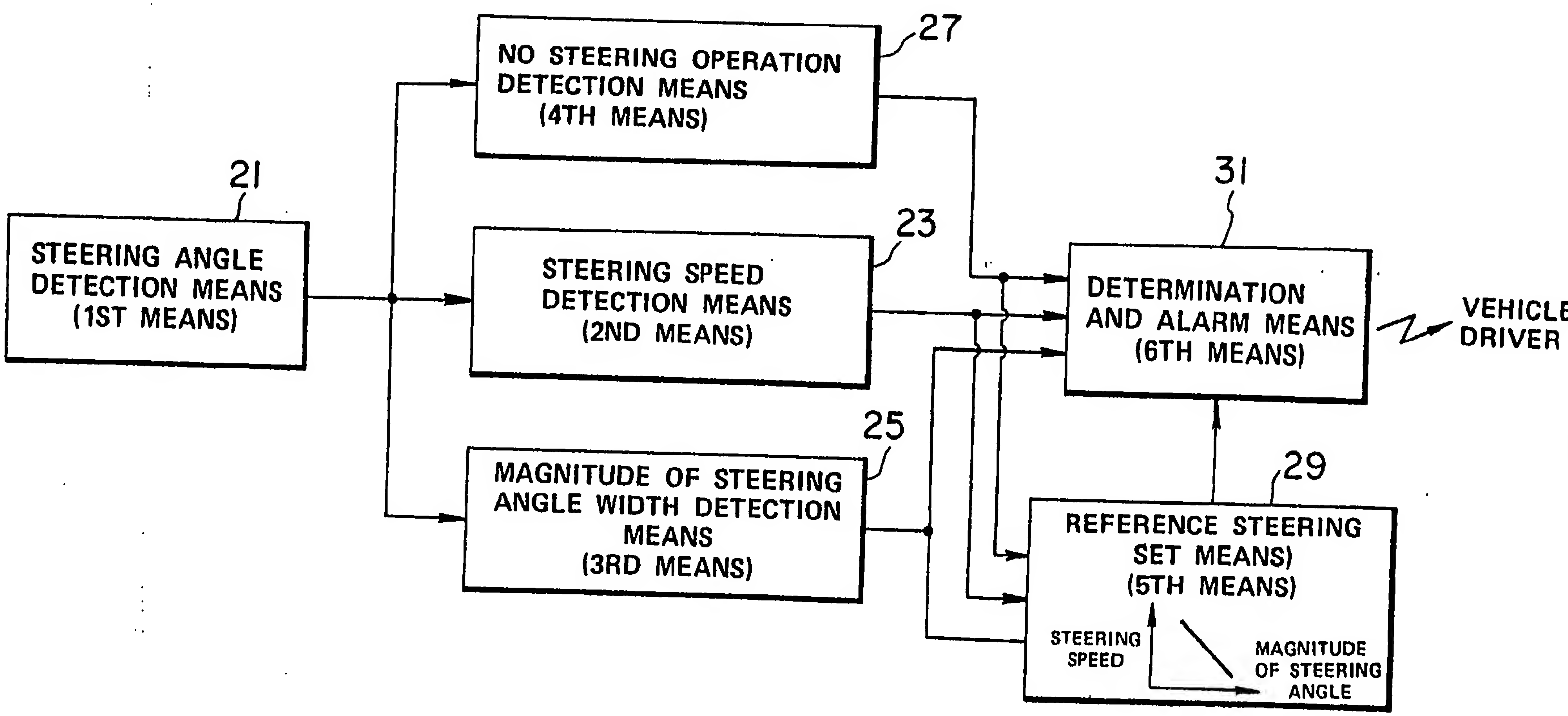
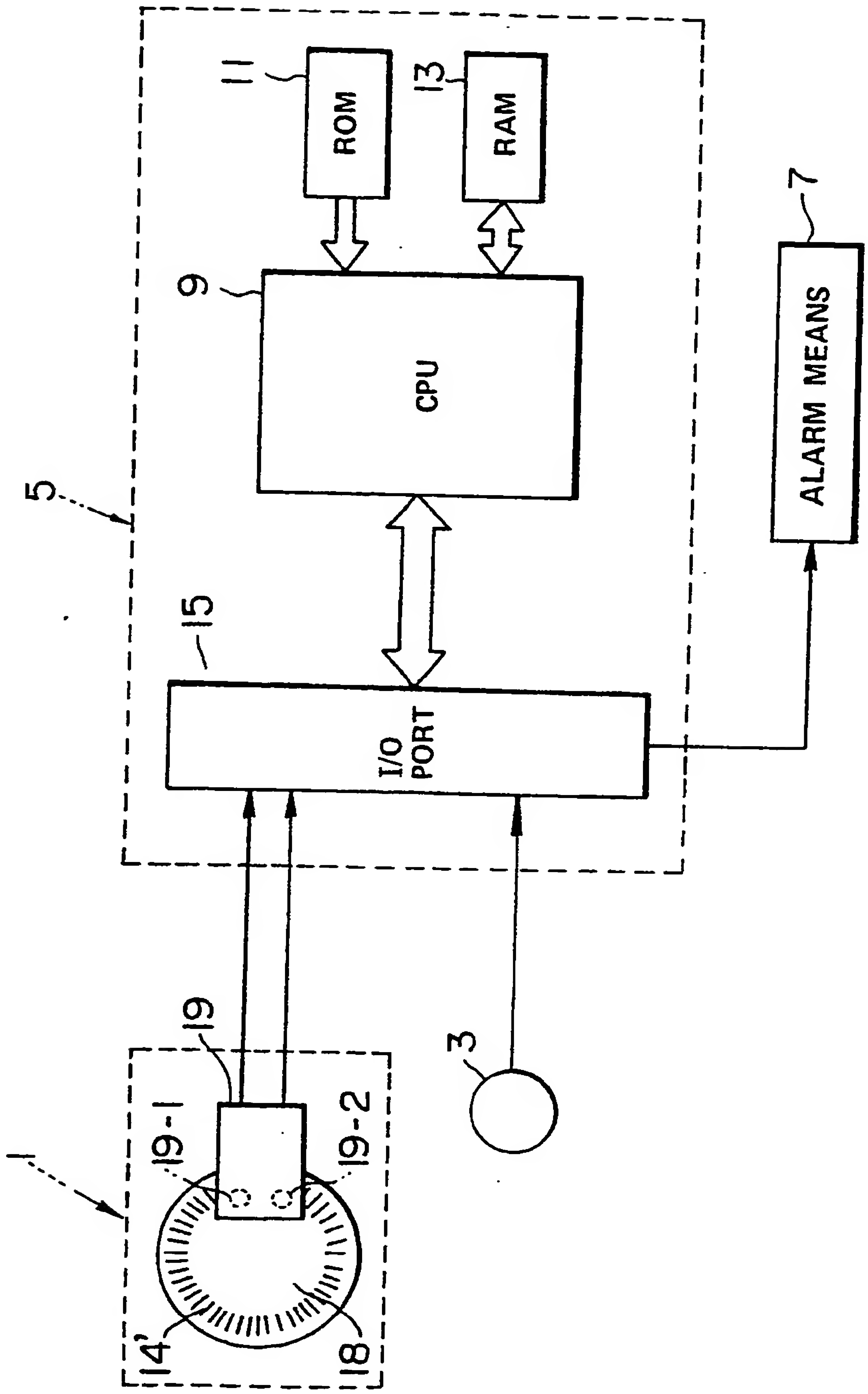

STEERING ANGLE DETECTION MEANS (1ST MEANS)
21
NO STEERING OPERATION DETECTION MEANS (4TH MEANS)
27
STEERING SPEED DETECTION MEANS (2ND MEANS)
23
MAGNITUDE OF STEERING ANGLE WIDTH DETECTION MEANS (3RD MEANS)
25
DETERMINATION AND ALARM MEANS (6TH MEANS)
31
VEHICLE DRIVER
REFERENCE STEERING SET MEANS) (5TH MEANS)
29
STEERING SPEED
MAGNITUDE OF STEERING ANGLE

FIG.2



3/17

FIG.3(A)

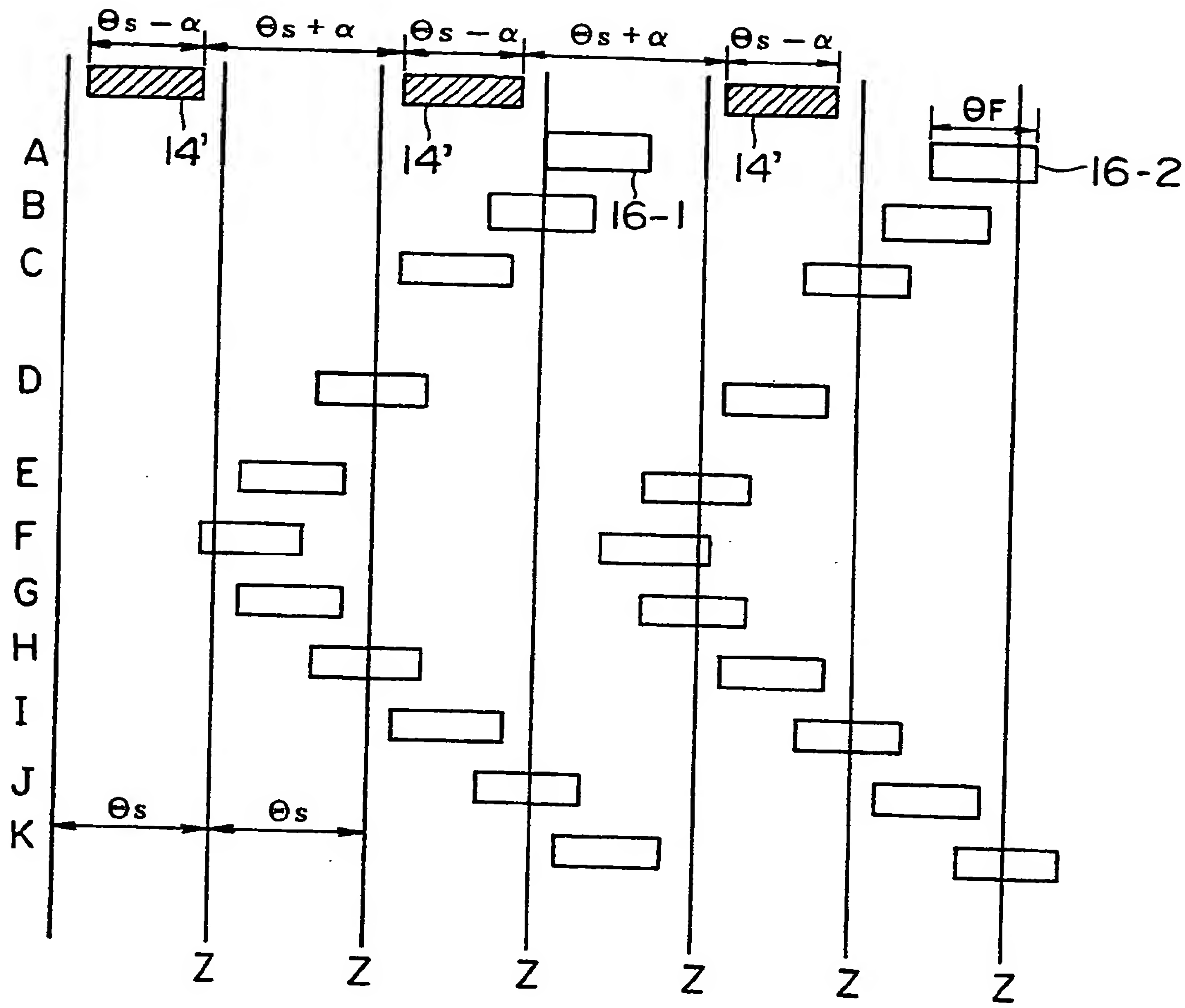


FIG.3(B)

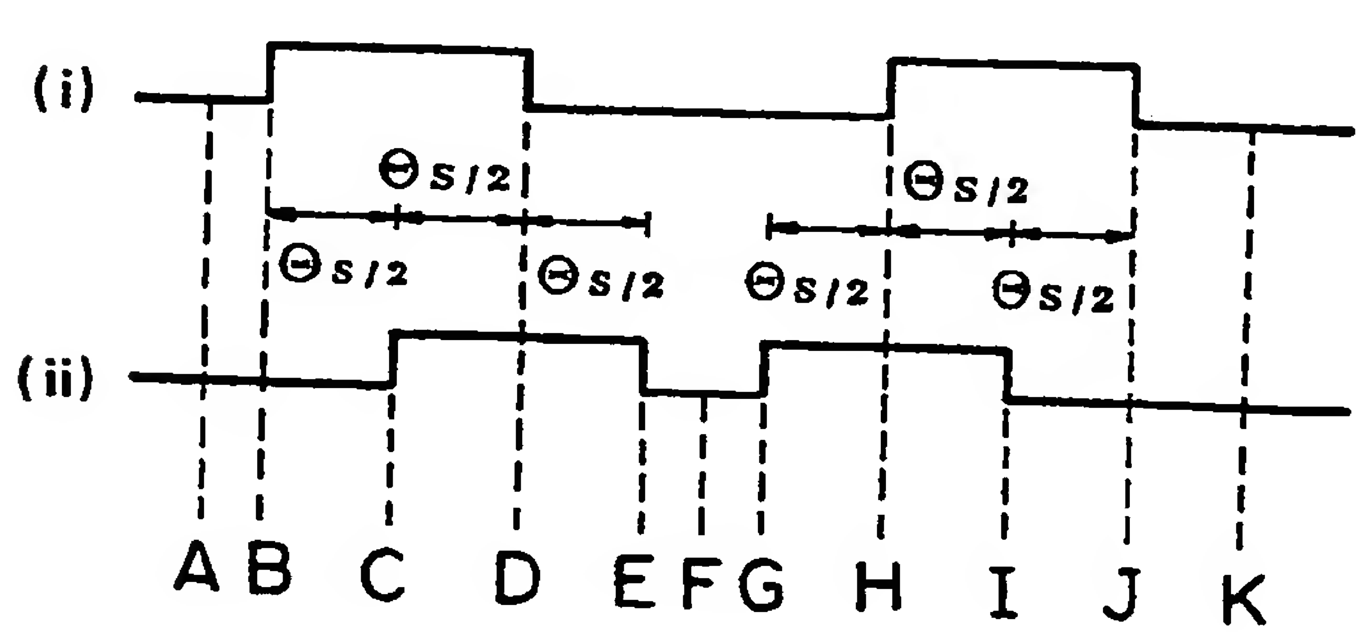


FIG.4

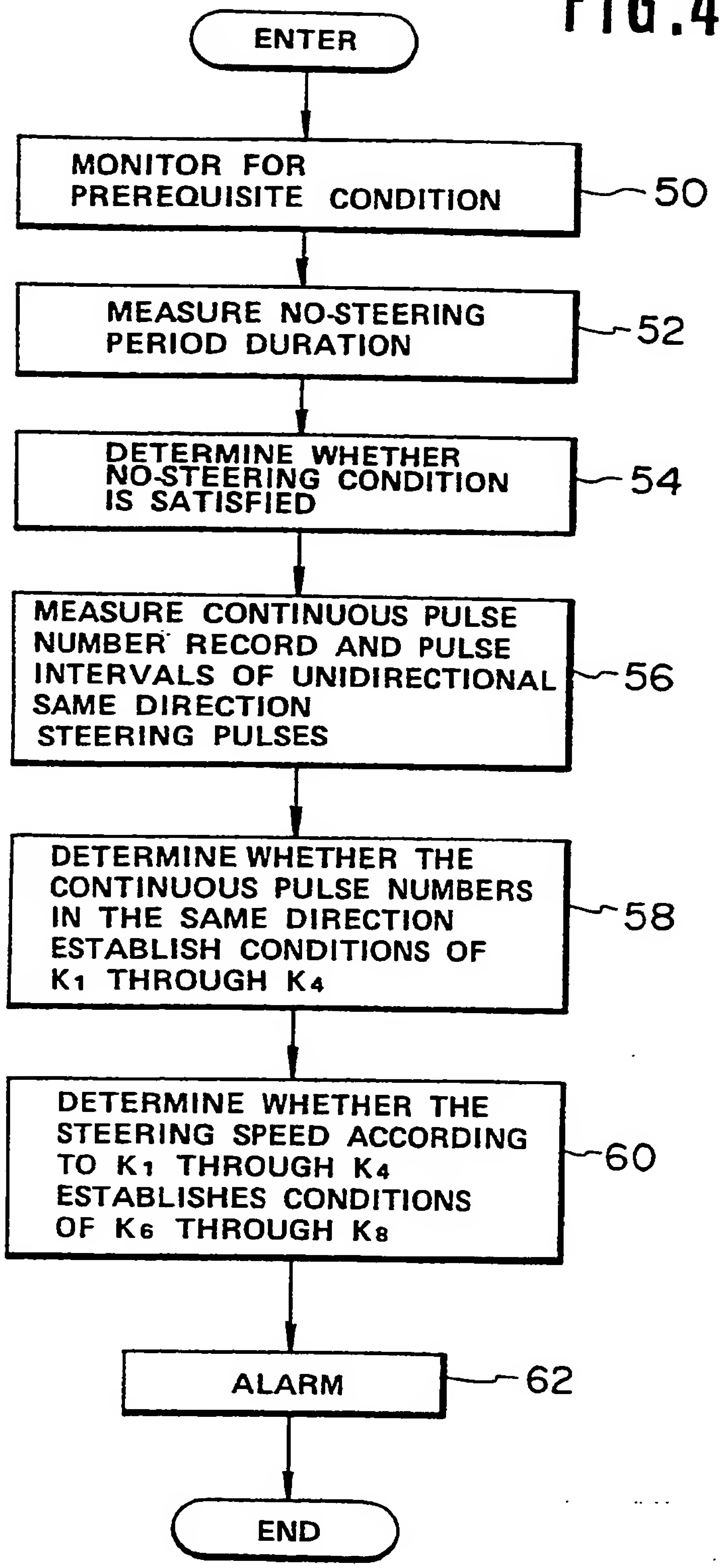

ENTER
MONITOR FOR PREREQUISITE CONDITION
50
MEASURE NO-STEERING PERIOD DURATION
52
DETERMINE WHETHER NO-STEERING CONDITION IS SATISFIED
54
MEASURE CONTINUOUS PULSE NUMBER RECORD AND PULSE INTERVALS OF UNIDIRECTIONAL SAME DIRECTION STEERING PULSES
56
DETERMINE WHETHER THE CONTINUOUS PULSE NUMBERS IN THE SAME DIRECTION ESTABLISH CONDITIONS OF K1 THROUGH K4
58
DETERMINE WHETHER THE STEERING SPEED ACCORDING TO K1 THROUGH K4 ESTABLISHES CONDITIONS OF K6 THROUGH K8
60
ALARM
62
END

FIG.5(a)

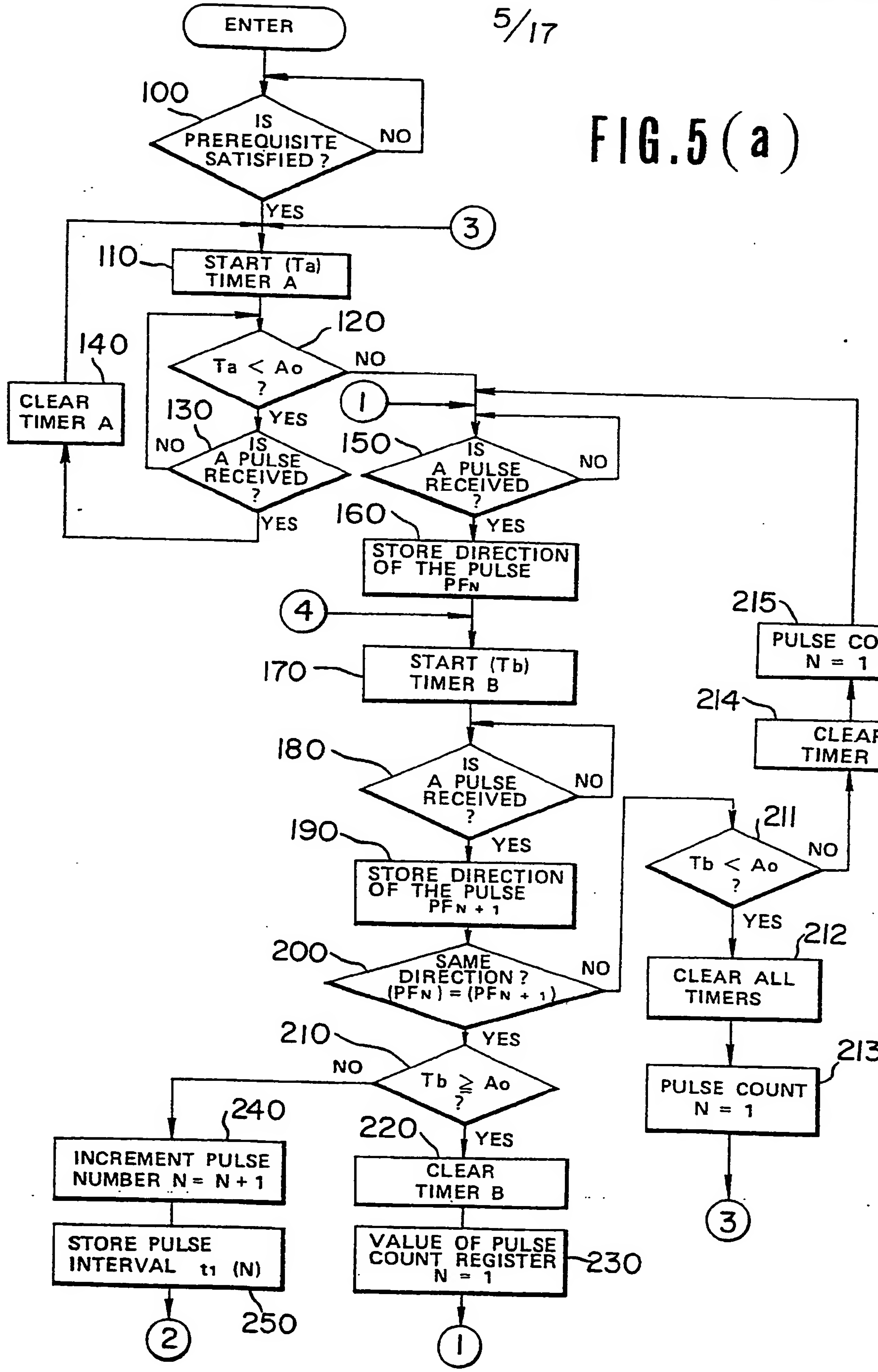

ENTER
100
IS PREREQUISITE SATISFIED ?
NO
YES
3
110
START (Ta) TIMER A
120
Ta < Ao ?
NO
YES
140
CLEAR TIMER A
130
NO
IS A PULSE RECEIVED ?
YES
1
150
IS A PULSE RECEIVED ?
NO
YES
160
STORE DIRECTION OF THE PULSE PFN
4
170
START (Tb) TIMER B
180
IS A PULSE RECEIVED ?
NO
YES
190
STORE DIRECTION OF THE PULSE PFN + 1
200
SAME DIRECTION ? (PFN) = (PFN + 1)
NO
YES
210
Tb ≧ Ao ?
NO
YES
240
INCREMENT PULSE NUMBER N = N + 1
STORE PULSE INTERVAL t1 (N)
250
2
220
CLEAR TIMER B
VALUE OF PULSE COUNT REGISTER N = 1
230
1
211
Tb < Ao ?
NO
YES
212
CLEAR ALL TIMERS
213
PULSE COUNT N = 1
3
214
CLEAR TIMER B
215
PULSE COUNT N = 1

FIG.5(b)

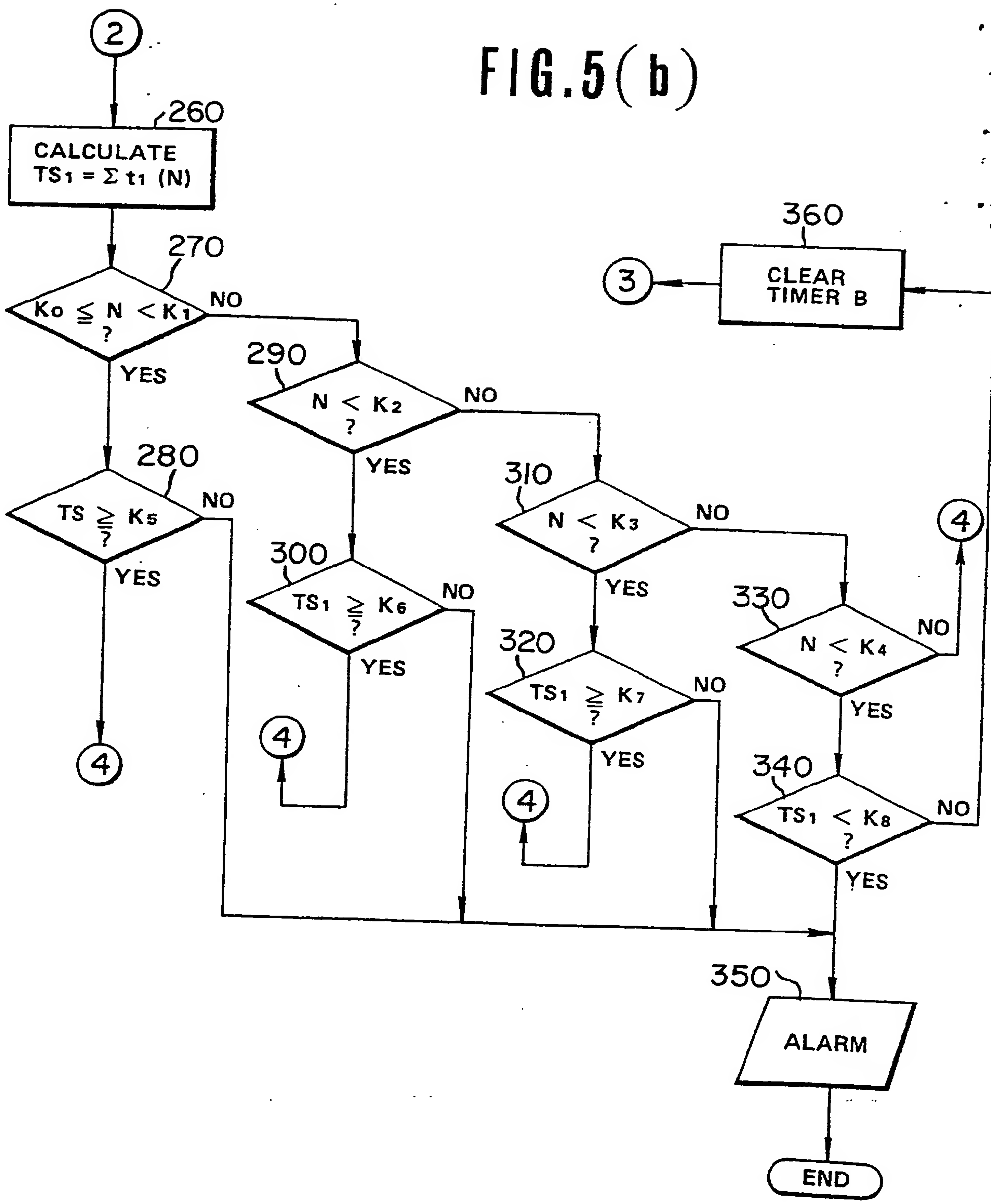

2
260
CALCULATE
TS1 = Σ t1 (N)
270
K0 ≦ N < K1 ?
NO
YES
280
TS ≧ K5 ?
NO
YES
4
290
N < K2 ?
NO
YES
300
TS1 ≧ K6 ?
NO
YES
4
310
N < K3 ?
NO
YES
320
TS1 ≧ K7 ?
NO
YES
4
330
N < K4 ?
NO
YES
4
340
TS1 < K8 ?
NO
YES
360
CLEAR
TIMER B
3
350
ALARM
END

FIG.6

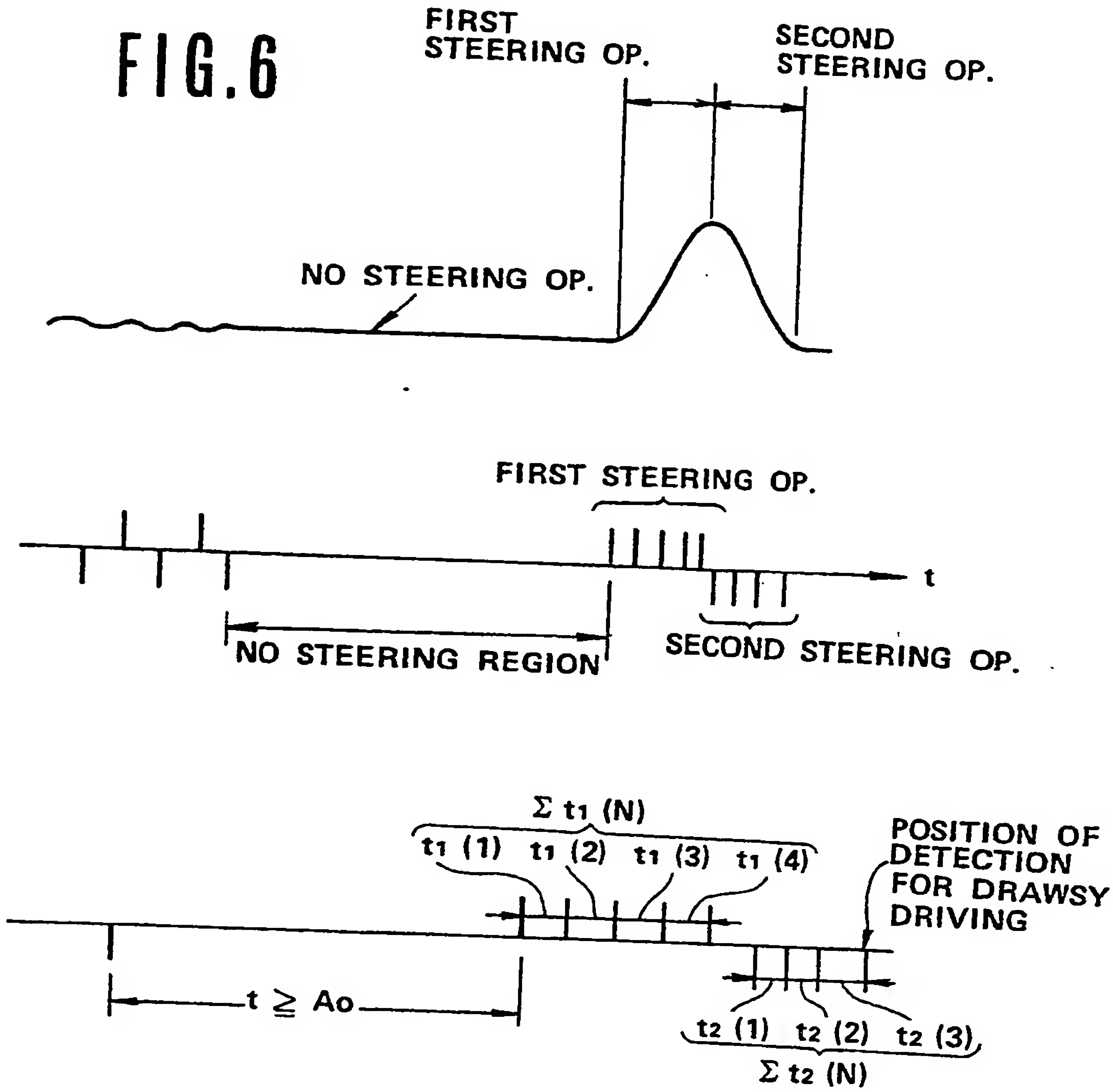
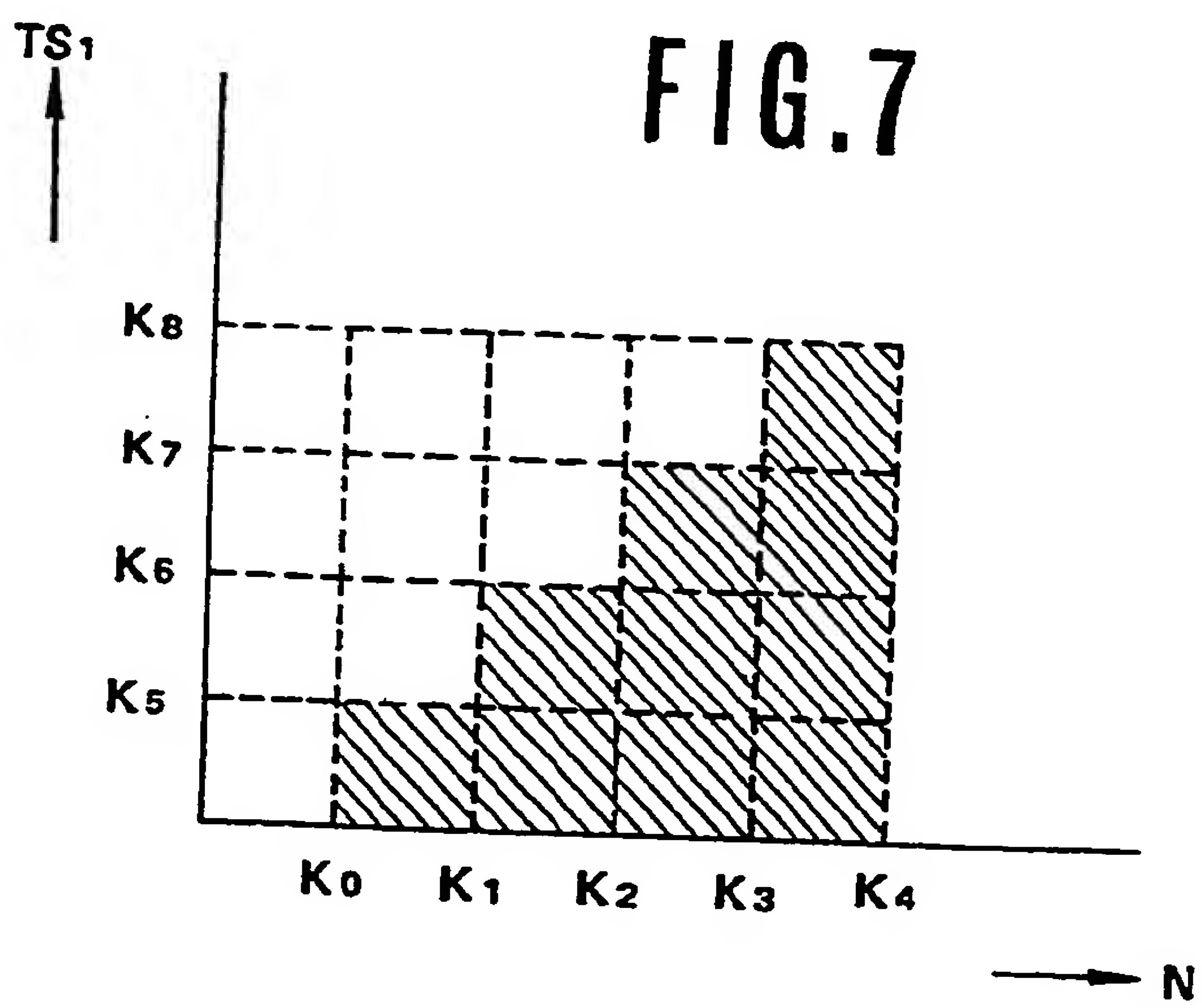

FIRST
STEERING OP.
SECOND
STEERING OP.
NO STEERING OP.
FIRST STEERING OP.
t
NO STEERING REGION
SECOND STEERING OP.
Σ t1 (N)
t1 (1) t1 (2) t1 (3) t1 (4)
POSITION OF
DETECTION
FOR DRAWSY
DRIVING
t ≧ Ao
t2 (1) t2 (2) t2 (3)
Σ t2 (N)

FIG.7


TS1
K8
K7
K6
K5
K0 K1 K2 K3 K4
N

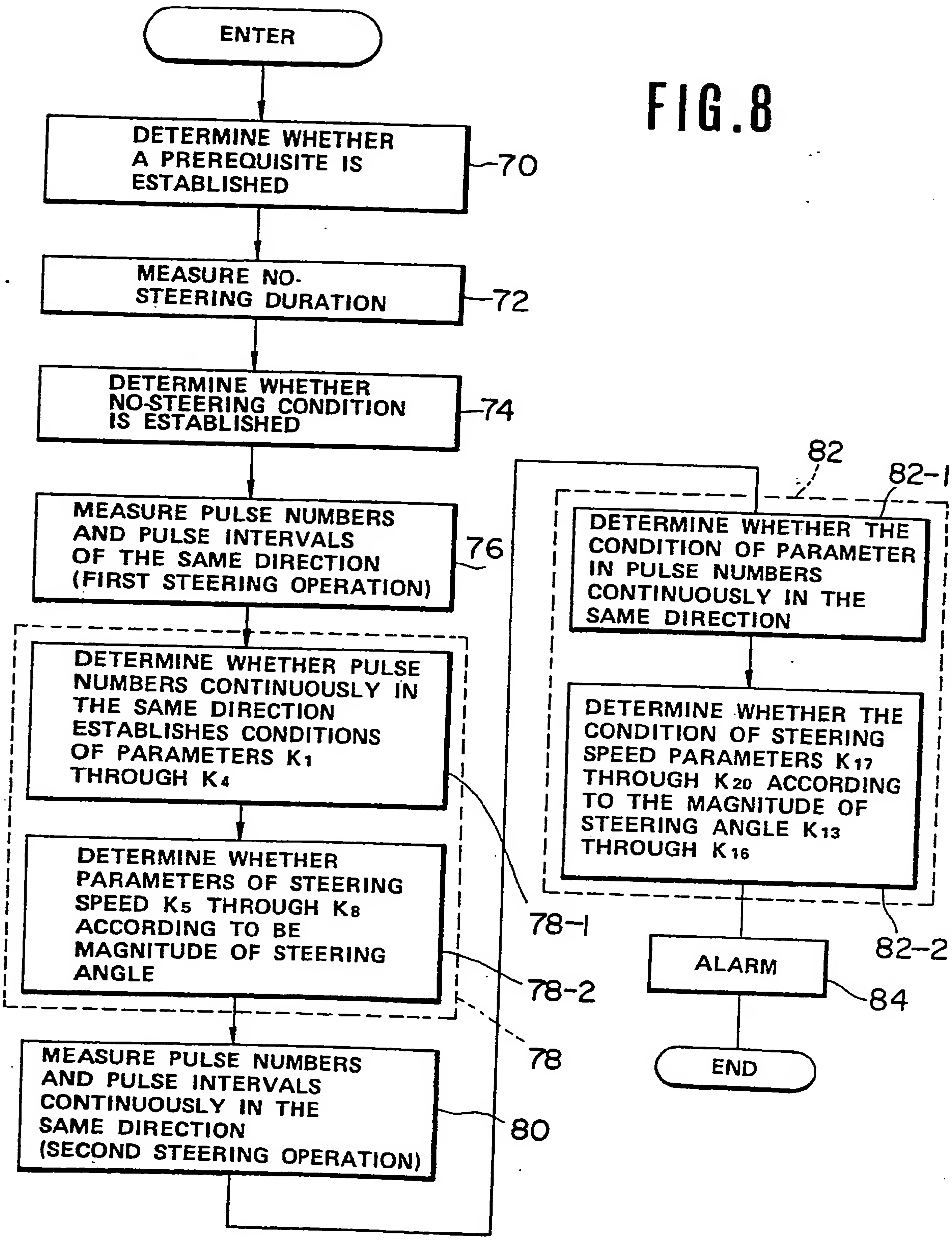

ENTER
DETERMINE WHETHER A PREREQUISITE IS ESTABLISHED
70
MEASURE NO-STEERING DURATION
72
DETERMINE WHETHER NO-STEERING CONDITION IS ESTABLISHED
74
MEASURE PULSE NUMBERS AND PULSE INTERVALS OF THE SAME DIRECTION (FIRST STEERING OPERATION)
76
DETERMINE WHETHER PULSE NUMBERS CONTINUOUSLY IN THE SAME DIRECTION ESTABLISHES CONDITIONS OF PARAMETERS K1 THROUGH K4
78-1
DETERMINE WHETHER PARAMETERS OF STEERING SPEED K5 THROUGH K8 ACCORDING TO BE MAGNITUDE OF STEERING ANGLE
78-2
78
MEASURE PULSE NUMBERS AND PULSE INTERVALS CONTINUOUSLY IN THE SAME DIRECTION (SECOND STEERING OPERATION)
80
82
82-1
DETERMINE WHETHER THE CONDITION OF PARAMETER IN PULSE NUMBERS CONTINUOUSLY IN THE SAME DIRECTION
DETERMINE WHETHER THE CONDITION OF STEERING SPEED PARAMETERS K17 THROUGH K20 ACCORDING TO THE MAGNITUDE OF STEERING ANGLE K13 THROUGH K16
82-2
ALARM
84
END

FIG.8

FIG.9(a)

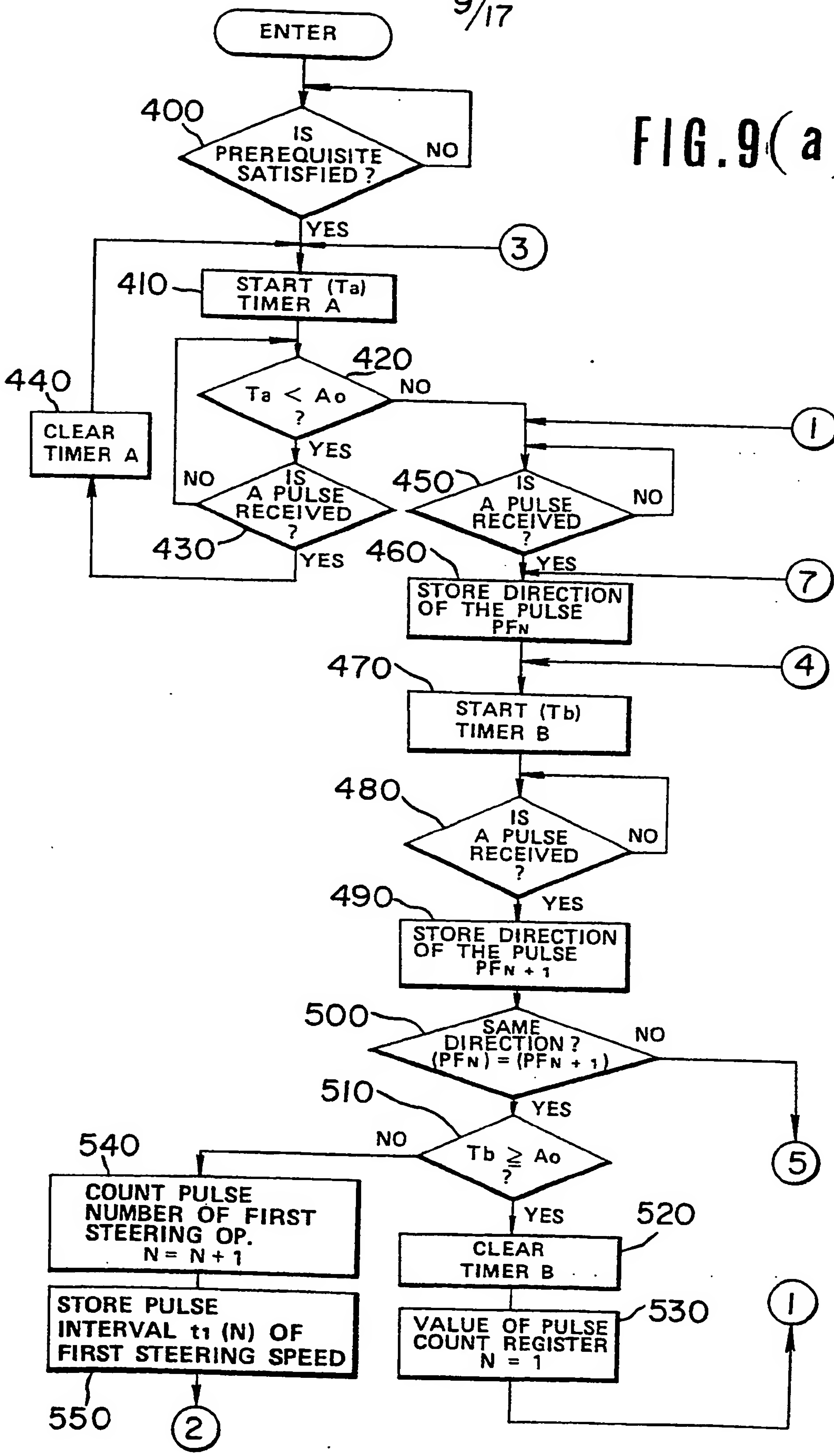

ENTER
400
IS PREREQUISITE SATISFIED ?
NO
YES
3
410
START (Ta) TIMER A
420
Ta < Ao ?
NO
YES
440
CLEAR TIMER A
NO
IS A PULSE RECEIVED ?
430
YES
1
450
IS A PULSE RECEIVED ?
NO
YES
460
STORE DIRECTION OF THE PULSE PFN
7
470
4
START (Tb) TIMER B
480
IS A PULSE RECEIVED ?
NO
YES
490
STORE DIRECTION OF THE PULSE PFN+1
500
SAME DIRECTION ? (PFN) = (PFN+1)
NO
510
YES
5
540
NO
Tb ≥ Ao ?
YES
520
COUNT PULSE NUMBER OF FIRST STEERING OP. N = N + 1
CLEAR TIMER B
STORE PULSE INTERVAL t1 (N) OF FIRST STEERING SPEED
VALUE OF PULSE COUNT REGISTER N = 1
530
1
550
2

FIG.9(b)

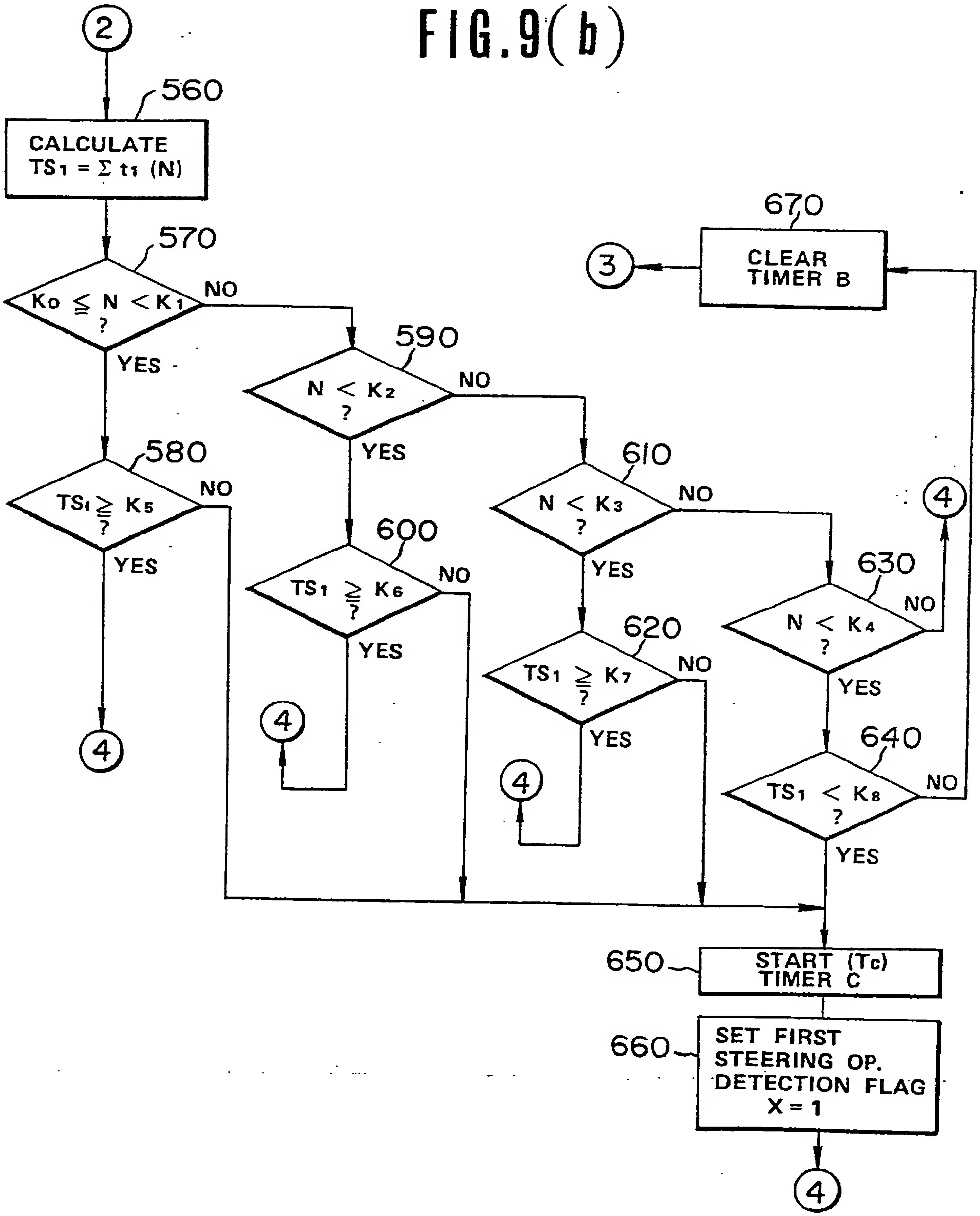

2
560
CALCULATE
$TS_1 = \Sigma t_1 (N)$
570
$K_0 \leqq N < K_1$?
NO
YES
590
$N < K_2$?
NO
YES
580
$TS_1 \gtreqless K_5$?
NO
YES
4
600
$TS_1 \gtreqless K_6$?
NO
YES
4
610
$N < K_3$?
NO
YES
620
$TS_1 \gtreqless K_7$?
NO
YES
4
630
$N < K_4$?
NO
YES
4
640
$TS_1 < K_8$?
NO
YES
670
CLEAR
TIMER B
3
650
START (T_C)
TIMER C
660
SET FIRST
STEERING OP.
DETECTION FLAG
X = 1
4

FIG.9(c)

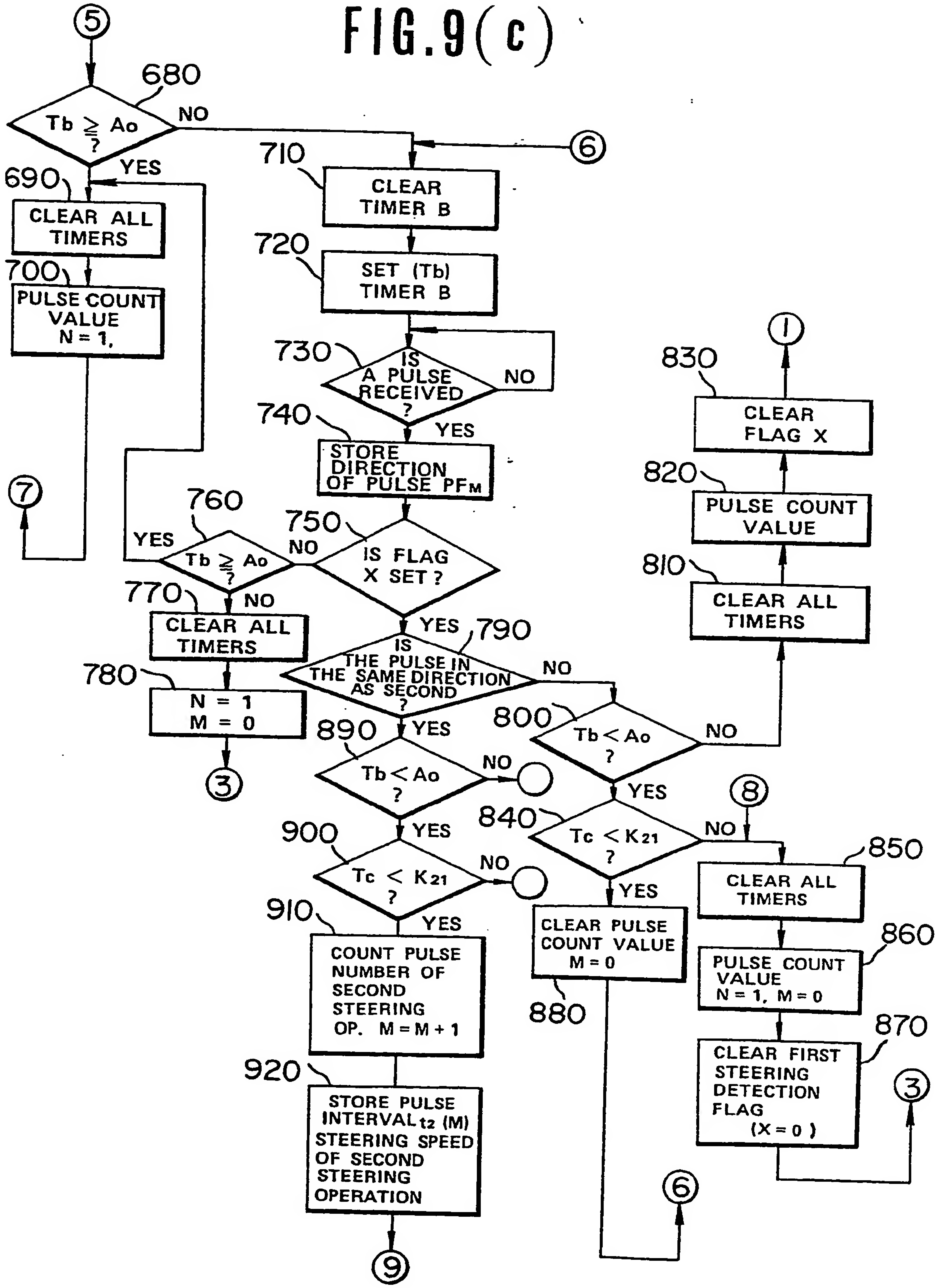

5
680
Tb ≧ Ao ?
NO
YES
6
710
CLEAR TIMER B
690
CLEAR ALL TIMERS
720
SET (Tb) TIMER B
700
PULSE COUNT VALUE N = 1.
730
IS A PULSE RECEIVED ?
NO
1
830
CLEAR FLAG X
740
YES
STORE DIRECTION OF PULSE PFM
820
PULSE COUNT VALUE
7
760
750
IS FLAG X SET ?
810
YES
Tb ≧ Ao ?
NO
CLEAR ALL TIMERS
770
NO
CLEAR ALL TIMERS
YES
790
780
IS THE PULSE IN THE SAME DIRECTION AS SECOND ?
NO
N = 1
M = 0
890
YES
800
Tb < Ao ?
NO
3
Tb < Ao ?
NO
YES
8
840
900
YES
Tc < K21 ?
NO
850
Tc < K21 ?
NO
CLEAR ALL TIMERS
YES
910
YES
CLEAR PULSE COUNT VALUE M = 0
860
COUNT PULSE NUMBER OF SECOND STEERING OP. M = M + 1
PULSE COUNT VALUE N = 1, M = 0
880
870
920
CLEAR FIRST STEERING DETECTION FLAG (X = 0)
3
STORE PULSE INTERVAL t2 (M) STEERING SPEED OF SECOND STEERING OPERATION
6
9

FIG.9(d)

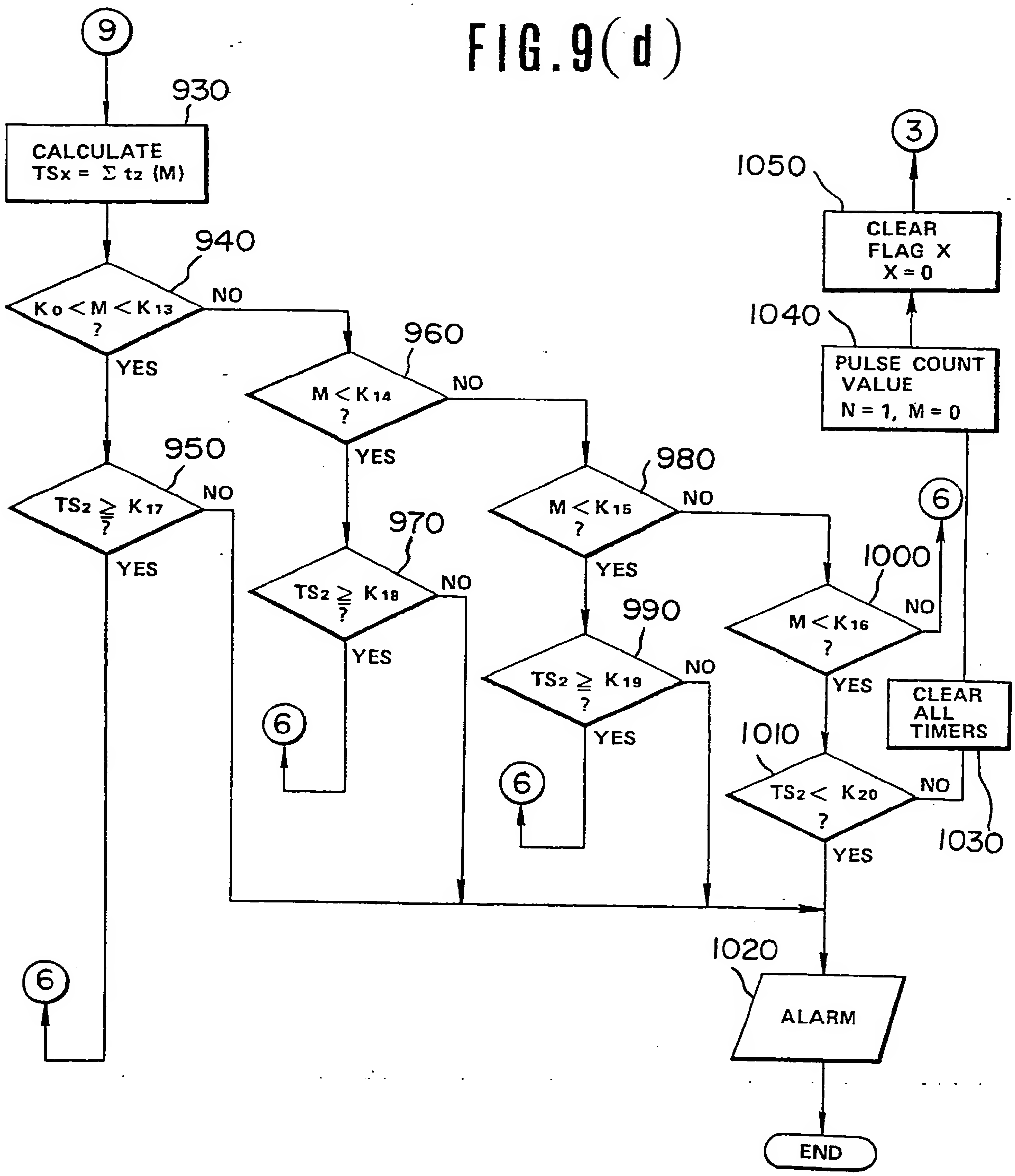

9
930
CALCULATE
TSx = Σ t2 (M)
940
K0 < M < K13
?
NO
YES
960
M < K14
?
NO
YES
950
TS2 ≧ K17
?
NO
YES
970
TS2 ≧ K18
?
NO
YES
6
980
M < K15
?
NO
YES
990
TS2 ≧ K19
?
NO
YES
6
1000
M < K16
?
NO
YES
6
1010
TS2 < K20
?
NO
YES
CLEAR
ALL
TIMERS
1030
1040
PULSE COUNT
VALUE
N = 1, M = 0
1050
CLEAR
FLAG X
X = 0
3
1020
ALARM
END
6

FIG. 11

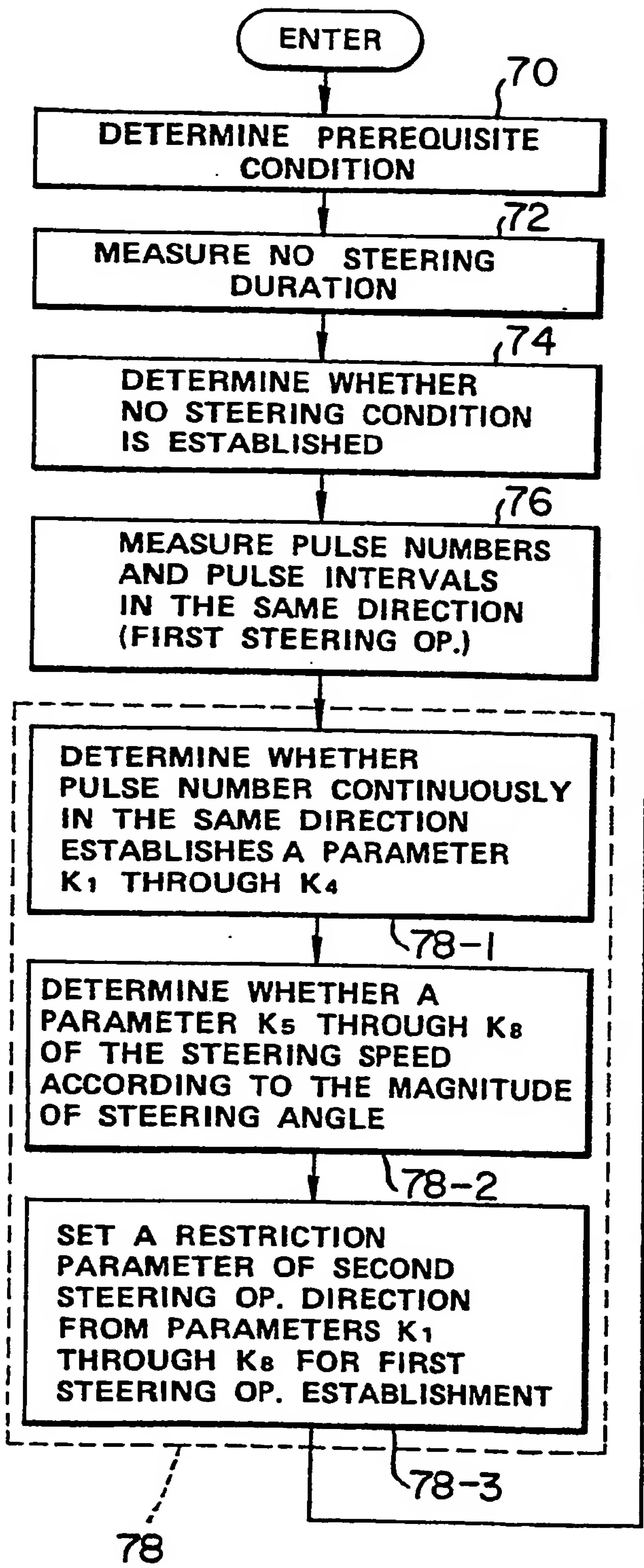
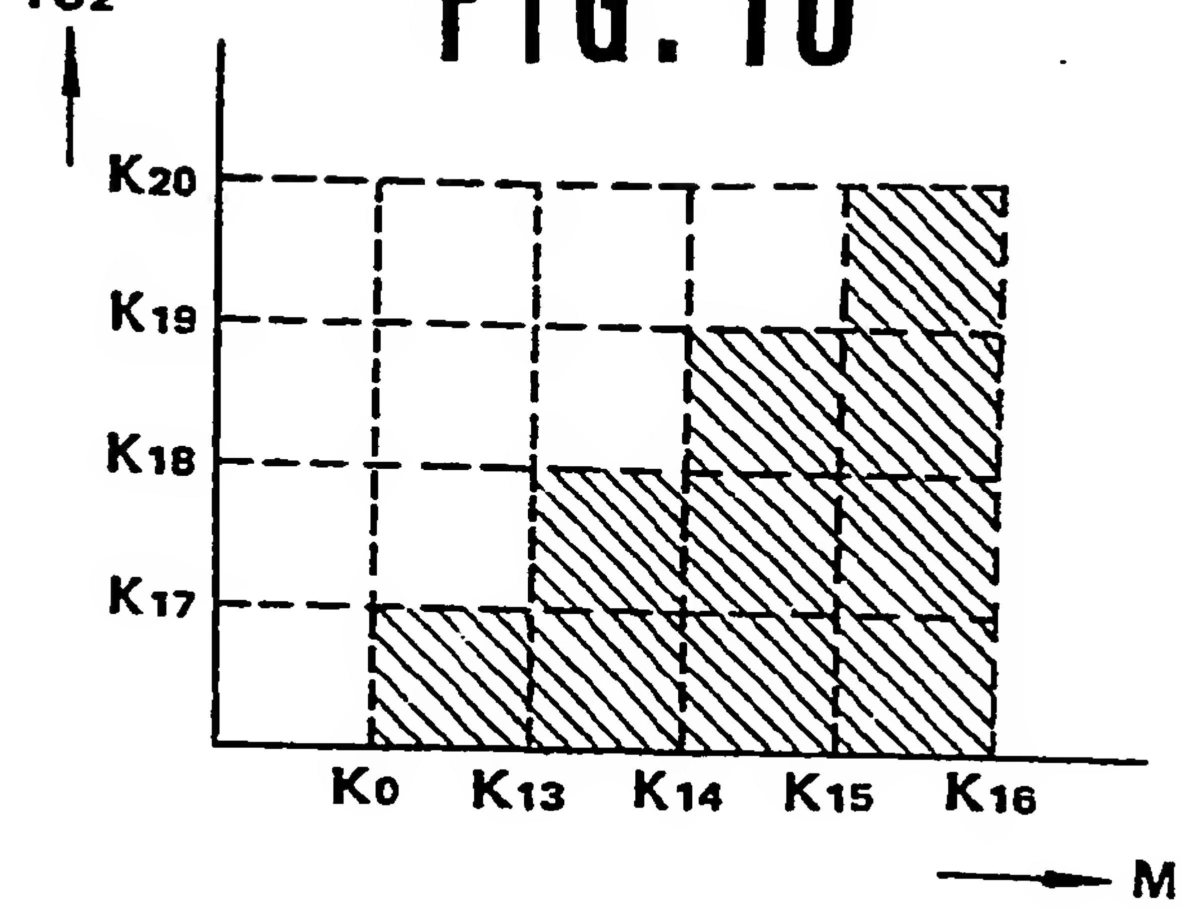

ENTER
70
DETERMINE PREREQUISITE CONDITION
72
MEASURE NO STEERING DURATION
74
DETERMINE WHETHER NO STEERING CONDITION IS ESTABLISHED
76
MEASURE PULSE NUMBERS AND PULSE INTERVALS IN THE SAME DIRECTION (FIRST STEERING OP.)
DETERMINE WHETHER PULSE NUMBER CONTINUOUSLY IN THE SAME DIRECTION ESTABLISHES A PARAMETER K1 THROUGH K4
78-1
DETERMINE WHETHER A PARAMETER K5 THROUGH K8 OF THE STEERING SPEED ACCORDING TO THE MAGNITUDE OF STEERING ANGLE
78-2
SET A RESTRICTION PARAMETER OF SECOND STEERING OP. DIRECTION FROM PARAMETERS K1 THROUGH K8 FOR FIRST STEERING OP. ESTABLISHMENT
78-3
78

FIG. 10


TS2
K20
K19
K18
K17
K0
K13
K14
K15
K16
M

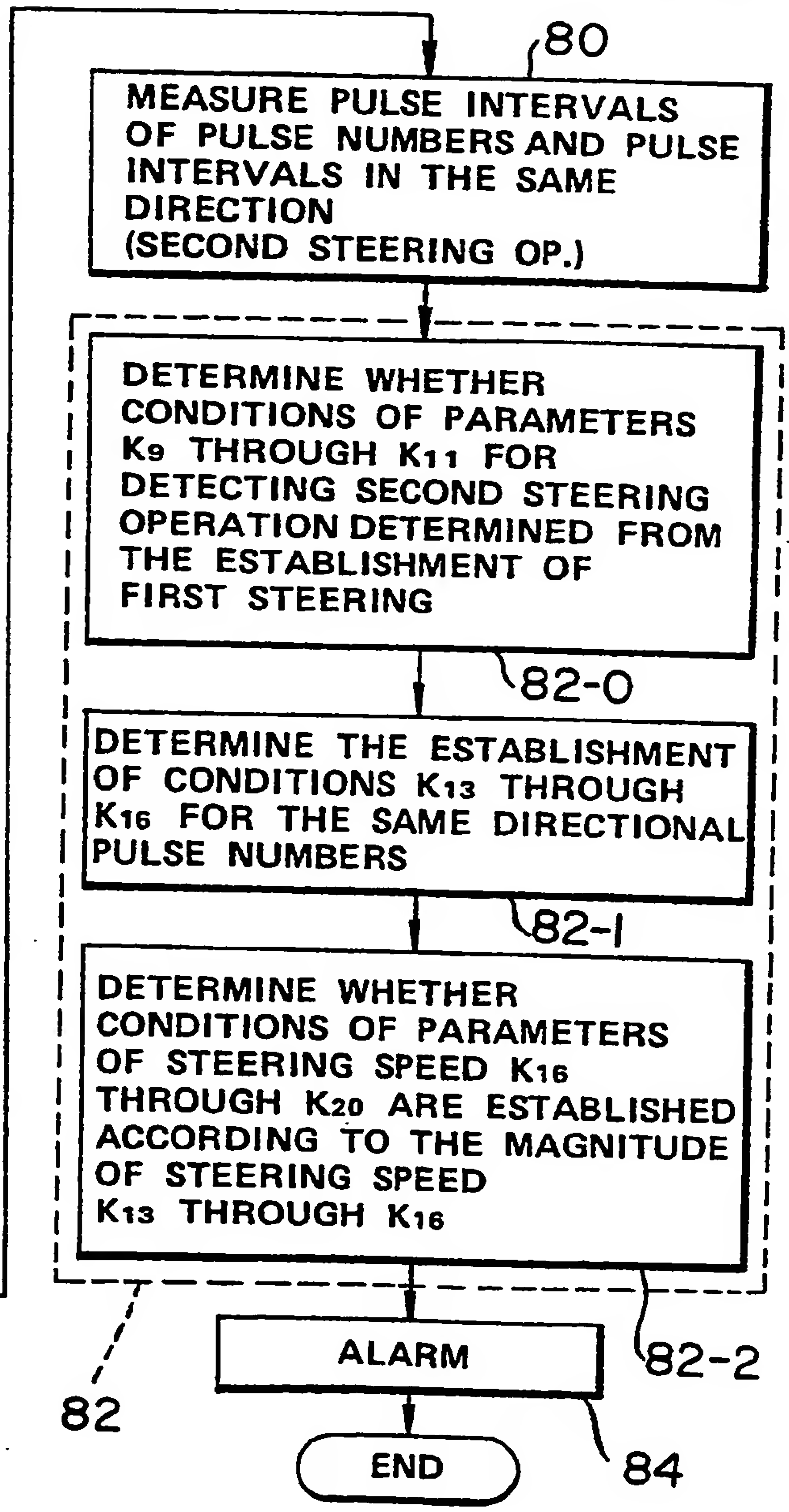

80
MEASURE PULSE INTERVALS OF PULSE NUMBERS AND PULSE INTERVALS IN THE SAME DIRECTION (SECOND STEERING OP.)
DETERMINE WHETHER CONDITIONS OF PARAMETERS K9 THROUGH K11 FOR DETECTING SECOND STEERING OPERATION DETERMINED FROM THE ESTABLISHMENT OF FIRST STEERING
82-0
DETERMINE THE ESTABLISHMENT OF CONDITIONS K13 THROUGH K16 FOR THE SAME DIRECTIONAL PULSE NUMBERS
82-1
DETERMINE WHETHER CONDITIONS OF PARAMETERS OF STEERING SPEED K16 THROUGH K20 ARE ESTABLISHED ACCORDING TO THE MAGNITUDE OF STEERING SPEED K13 THROUGH K16
82-2
82
ALARM
84
END

FIG.12(a)

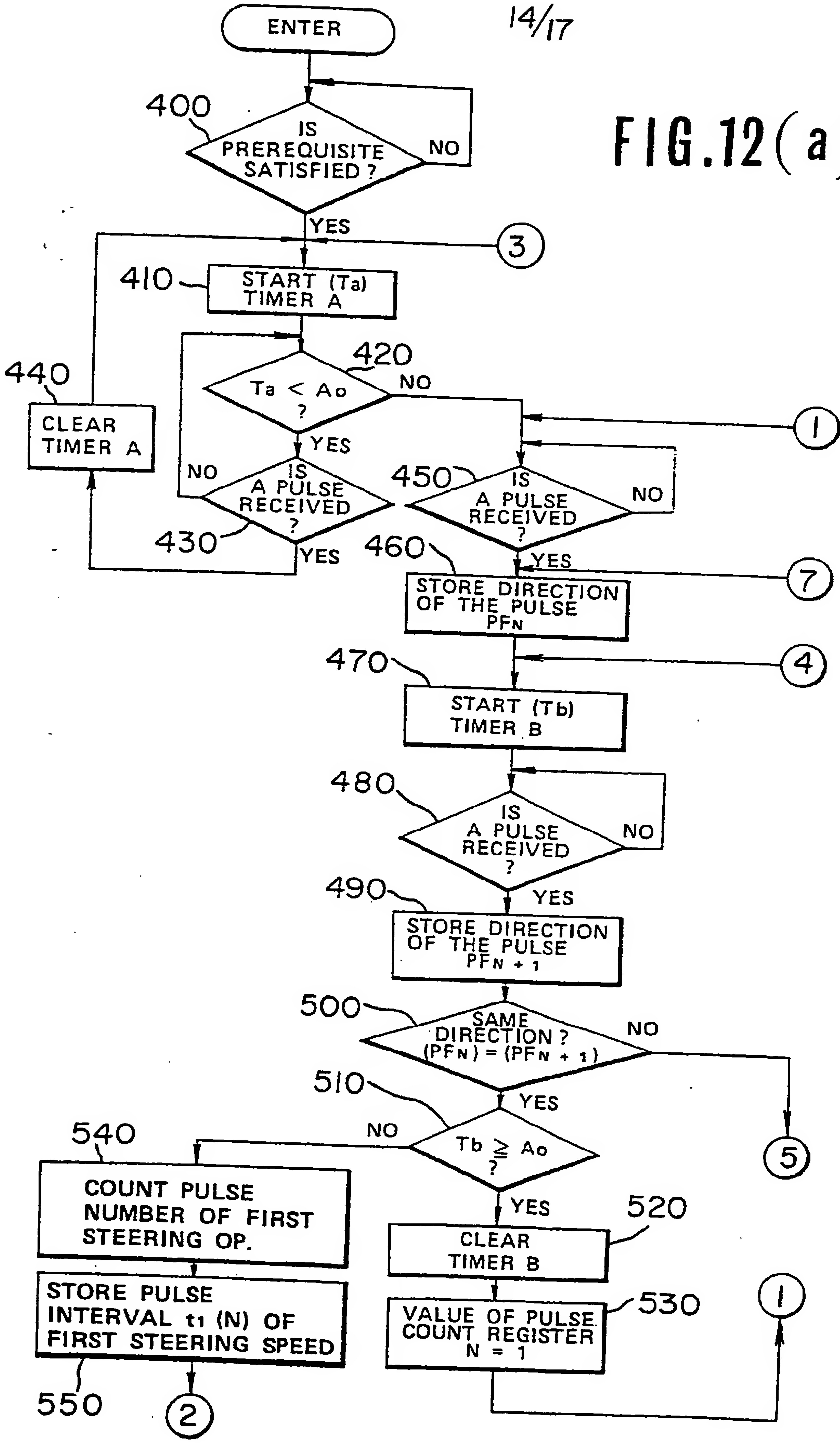

ENTER
400
IS PREREQUISITE SATISFIED ?
NO
YES
3
410
START (Ta) TIMER A
420
Ta < Ao ?
NO
YES
440
CLEAR TIMER A
1
NO
IS A PULSE RECEIVED ?
430
YES
450
IS A PULSE RECEIVED ?
NO
460
YES
7
STORE DIRECTION OF THE PULSE PFN
470
4
START (Tb) TIMER B
480
IS A PULSE RECEIVED ?
NO
490
YES
STORE DIRECTION OF THE PULSE PFN + 1
500
SAME DIRECTION ? (PFN) = (PFN + 1)
NO
510
YES
540
NO
Tb ≧ Ao ?
5
COUNT PULSE NUMBER OF FIRST STEERING OP.
YES
520
CLEAR TIMER B
STORE PULSE INTERVAL t1 (N) OF FIRST STEERING SPEED
VALUE OF PULSE COUNT REGISTER N = 1
530
1
550
2

FIG. 12(b)

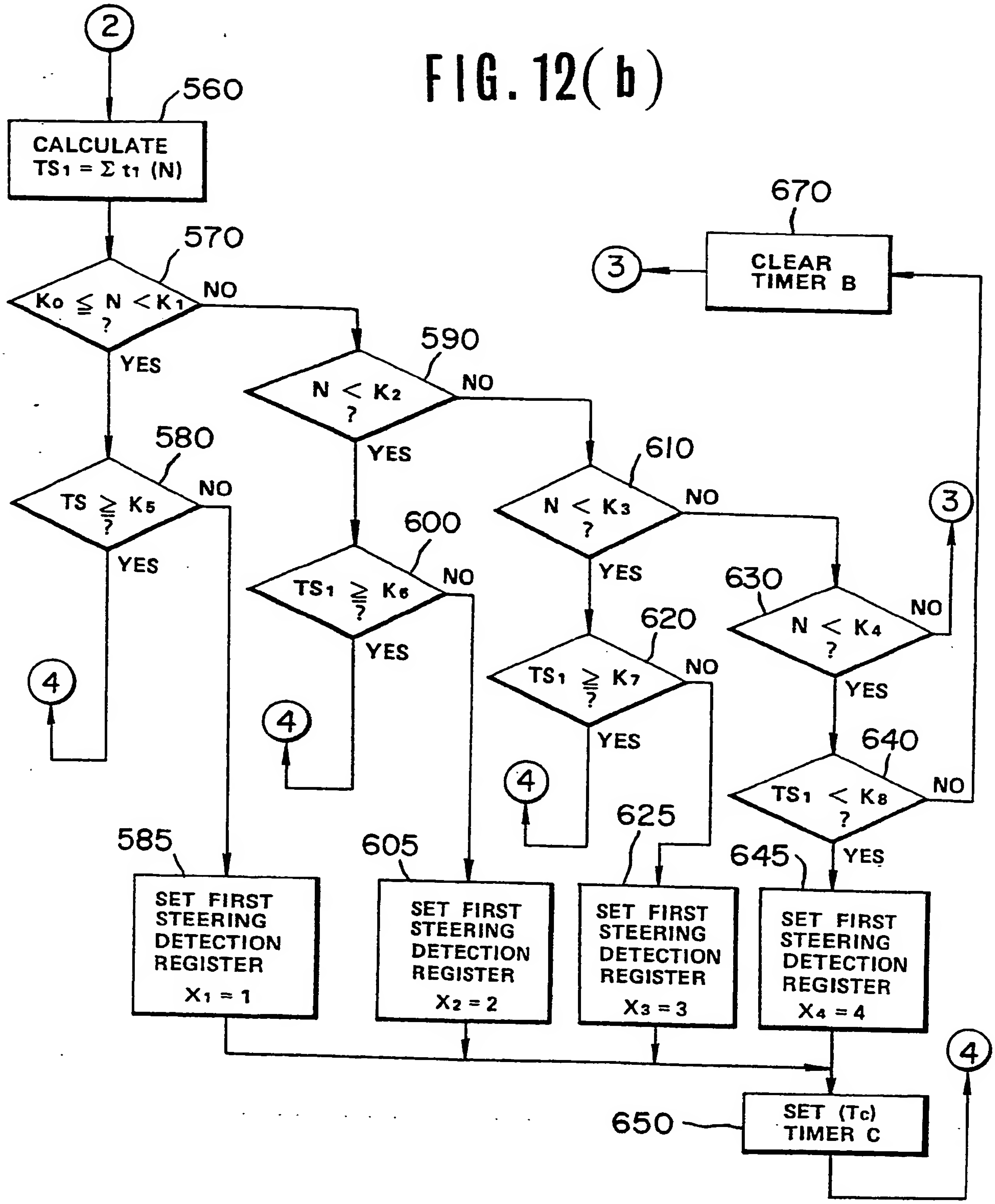

2
560
CALCULATE
TS1 = Σ t1 (N)
570
Ko ≦ N < K1 ?
NO
YES
590
N < K2 ?
NO
YES
580
TS ≧ K5 ?
NO
YES
600
TS1 ≧ K6 ?
NO
YES
610
N < K3 ?
NO
YES
620
TS1 ≧ K7 ?
NO
YES
630
N < K4 ?
NO
YES
640
TS1 < K8 ?
NO
YES
670
CLEAR TIMER B
3
4
585
SET FIRST STEERING DETECTION REGISTER
X1 = 1
605
SET FIRST STEERING DETECTION REGISTER
X2 = 2
625
SET FIRST STEERING DETECTION REGISTER
X3 = 3
645
SET FIRST STEERING DETECTION REGISTER
X4 = 4
650
SET (Tc) TIMER C

FIG.12(c)

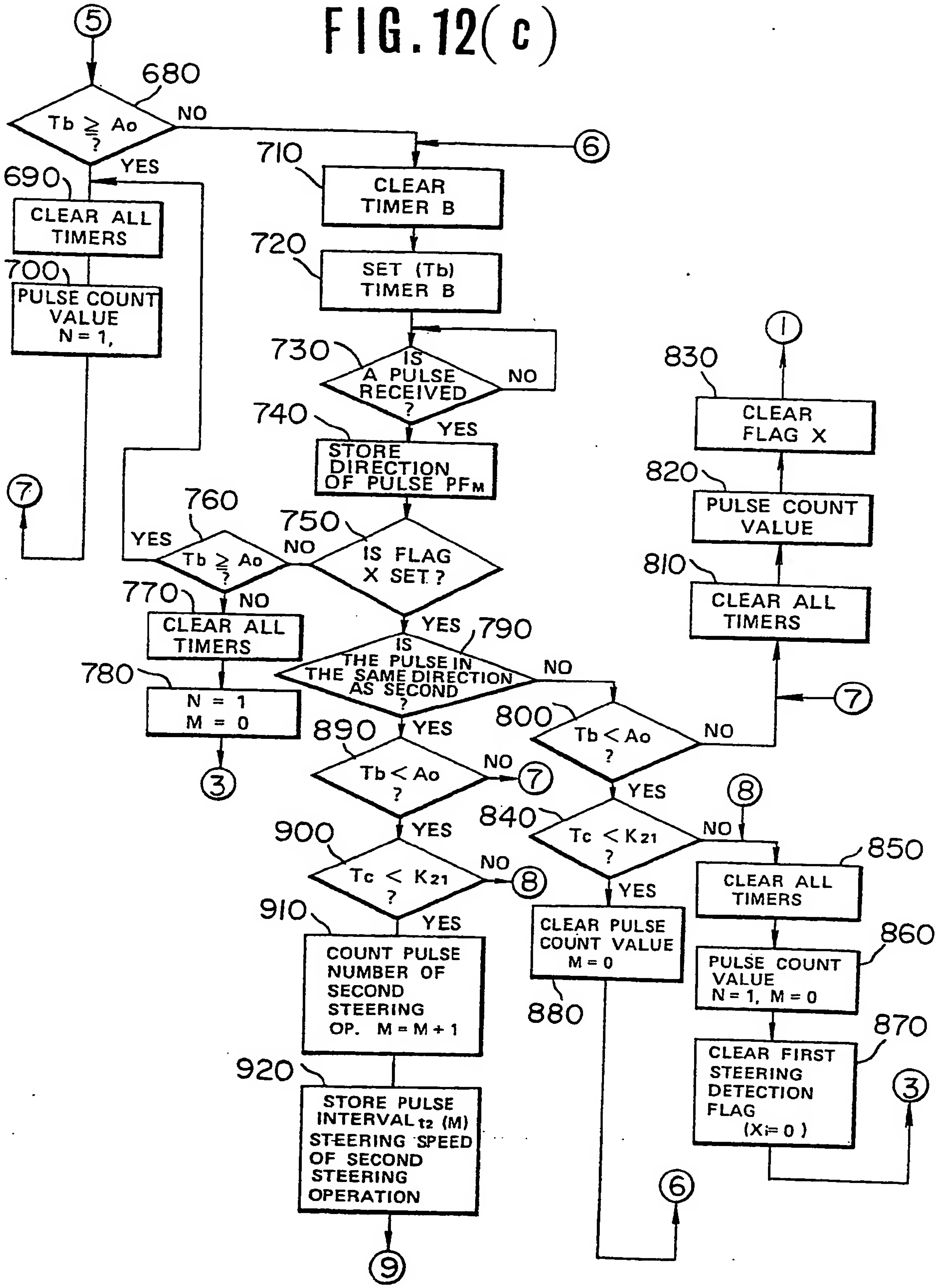
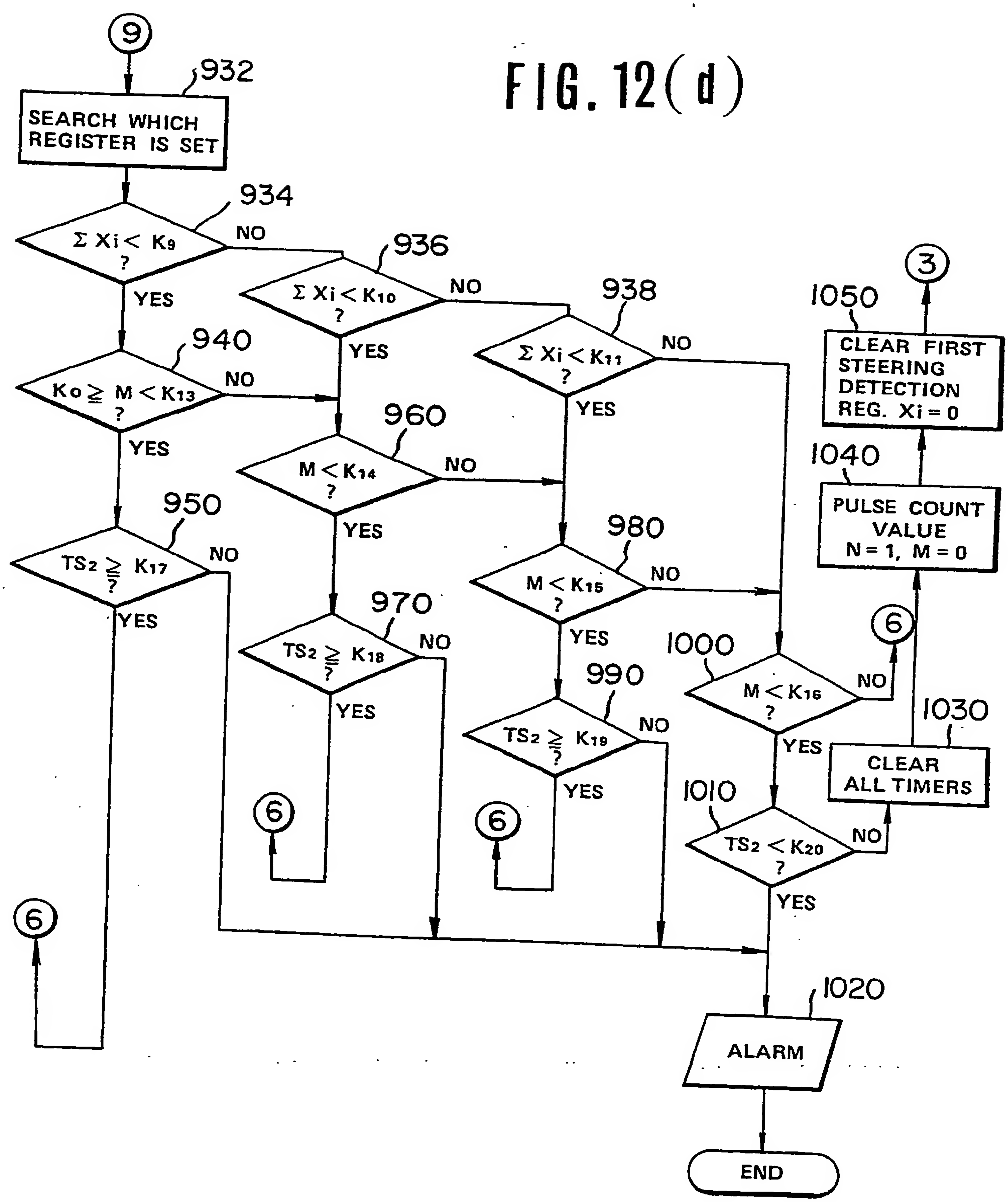

5
680
Tb ≧ Ao ?
NO
YES
6
710
CLEAR TIMER B
690
CLEAR ALL TIMERS
720
SET (Tb) TIMER B
700
PULSE COUNT VALUE N = 1,
730
IS A PULSE RECEIVED ?
NO
YES
740
STORE DIRECTION OF PULSE PFM
1
830
CLEAR FLAG X
820
PULSE COUNT VALUE
810
CLEAR ALL TIMERS
7
760
750
IS FLAG X SET ?
YES
NO
Tb ≧ Ao ?
770
NO
CLEAR ALL TIMERS
YES
790
IS THE PULSE IN THE SAME DIRECTION AS SECOND ?
NO
780
N = 1
M = 0
7
3
890
YES
800
Tb < Ao ?
NO
Tb < Ao ?
NO
7
YES
8
900
YES
840
Tc < K21 ?
NO
850
Tc < K21 ?
NO
8
CLEAR ALL TIMERS
YES
910
YES
CLEAR PULSE COUNT VALUE M = 0
860
COUNT PULSE NUMBER OF SECOND STEERING OP. M = M + 1
PULSE COUNT VALUE N = 1, M = 0
880
870
920
CLEAR FIRST STEERING DETECTION FLAG (Xi = 0)
3
STORE PULSE INTERVAL t2 (M) STEERING SPEED OF SECOND STEERING OPERATION
6
9

FIG. 12(d)


9
932
SEARCH WHICH REGISTER IS SET
934
Σ Xi < K9 ?
NO
YES
936
Σ Xi < K10 ?
NO
YES
938
Σ Xi < K11 ?
NO
YES
940
Ko ≧ M < K13 ?
NO
YES
960
M < K14 ?
NO
YES
950
TS2 ≧ K17 ?
NO
YES
980
M < K15 ?
NO
YES
970
TS2 ≧ K18 ?
NO
YES
990
TS2 ≧ K19 ?
NO
YES
1000
M < K16 ?
NO
YES
1010
TS2 < K20 ?
NO
YES
6
1030
CLEAR ALL TIMERS
1040
PULSE COUNT VALUE N = 1, M = 0
1050
CLEAR FIRST STEERING DETECTION REG. Xi = 0
3
1020
ALARM
END

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(71) Applicant: NISSAN MOTOR CO., LTD.
No.2, Takara-cho, Kanagawa-ku
Yokohama-shi Kanagawa-ken 221(JP)

(72) Inventor: Obara, Hideo
68, Oppamahigashi-cho 3-chome
Yokosuka-shi Kanagawa-ken(JP)

(72) Inventor: Yanagishima, Takayuki
1-7-404, Maborikaigan 4-chome
Yokosuka-shi Kanagawa-ken(JP)

(72) Inventor: Seko, Yasutoshi
2781-19, Tomioka Kanazawa-ku
Yokohama-shi Kanagawa-ken(JP)

(74) Representative: Patentanwälte TER MEER - MÜLLER - STEINMEISTER
Mauerkircherstrasse 45
D-8000 München 80(DE)

(54) System and method for detecting and warning of drowsy driving of a vehicle.

(57) In a drowsy driving detection system, drowsiness is recognized when an extended period without any steering adjustments is followed by abrupt steering corrections, of at least minimal speed and extent, in both directions. The minimal speed values are selected in accordance with the detected angular extent of each steering correction. The extent of each steering correction may be subdivided into a number of ranges, each associated with a predetermined reference minimal steering speed value. The reference speed value selection process may be applied to the steering corrections in either or both directions.

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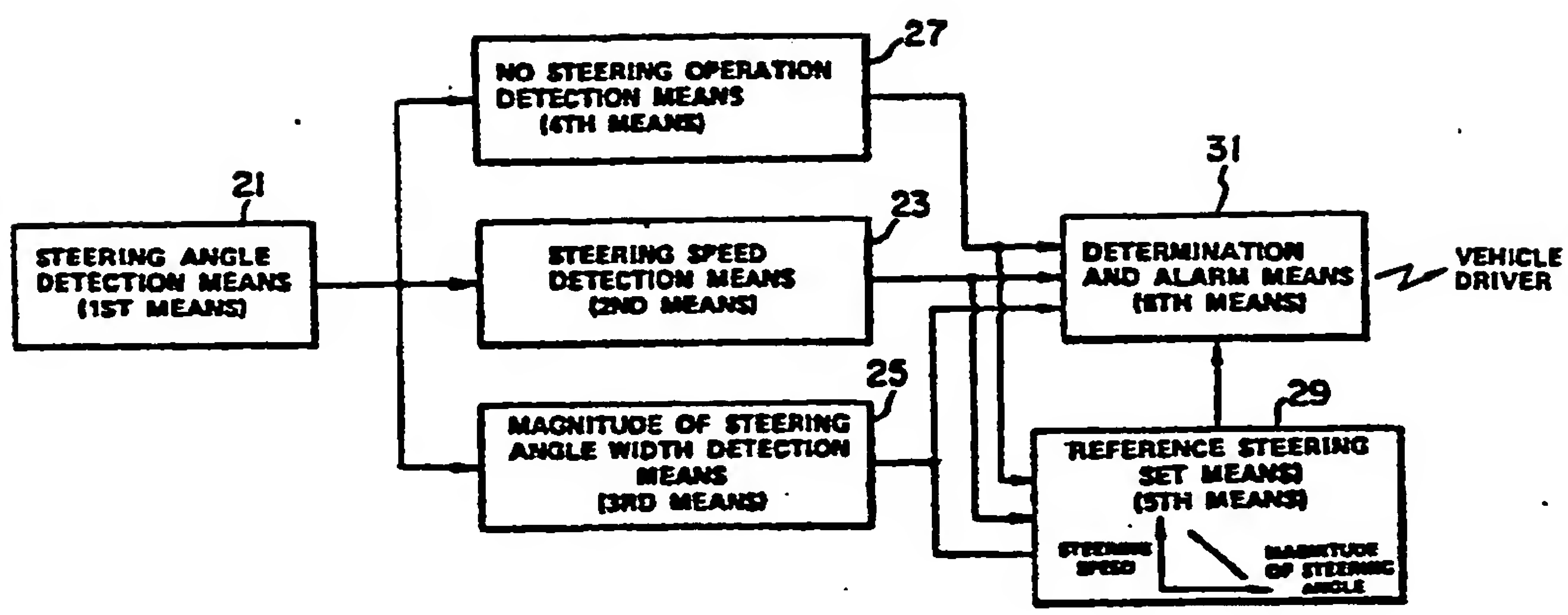
FIG.1


27
NO STEERING OPERATION DETECTION MEANS (4TH MEANS)
21
STEERING ANGLE DETECTION MEANS (1ST MEANS)
23
STEERING SPEED DETECTION MEANS (2ND MEANS)
25
MAGNITUDE OF STEERING ANGLE WIDTH DETECTION MEANS (3RD MEANS)
31
DETERMINATION AND ALARM MEANS (6TH MEANS)
VEHICLE DRIVER
29
REFERENCE STEERING SET MEANS (5TH MEANS)
STEERING SPEED
MAGNITUDE OF STEERING ANGLE

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EUROPEAN SEARCH REPORT

0147539

Application number

EP 84 11 1577

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
P,D A	EP-A-0 119 483 (NISSAN)		B 60 K 28/00 G 08 B 21/00

P,D A	EP-A-0 117 497 (NISSAN)		

P,D A	EP-A-0 119 484 (NISSAN)		

P,D A	EP-A-0 119 486 (NISSAN)		

P,A	EP-A-0 119 485 (NISSAN)		
	---		TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	EP-A-0 059 225 (NISSAN) * Claims; figure 13 *	1,10	

A	DE-A-2 042 853 (LICENTIA) * The whole document *	1,10	B 60 K 28/00 G 08 B 21/00

A	EP-A-0 061 500 (NISSAN)		

A	EP-A-0 048 492 (NISSAN)		
	--- -/-		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	03-05-1985	BEYER F.

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0147539

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Application number

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A	US-A-3 794 969 (F.R.KLOPFENSTEIN et al.) ---		
A	DE-A-2 516 675 (NISSAN) ---		
A	DE-A-2 509 354 (NIPPON SOKEN, INC.) ---		
A	US-A-3 222 640 (D.O.WURST) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

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